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Article

Strategic Advantage in the sky. Gaming Expertise and Operational Efficiency: Unveiling the Lower Perceived Workload and Potential Benefits of Gamers as Drone Pilots

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INFORMATION

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ABSTRACT

Background. Unmanned aerial vehicles (UAV) play a crucial role in modern military and civilian operations, requiring peak cognitive performance from their pilots. Drone pilots often experience attention lapses and performance reductions, which can jeopardize mission success, task performance, and their well-being. Existing research shows that video game players outperform non-gamers in certain cognitive abilities, such as visual tracking, attention, and mental rotation. This study explores how video game experience may shape the skills and workload perception of potential UAV pilots. **Method**. A pilot study was conducted with two groups: gamers (n = 22) and non-gamers (n = 29). Participants carried out simulated drone flight tasks using a *Phantom 3* on the *Aerosim RC* simulator. Performance and workload were assessed using the AWT, a test derived from the NASA-TLX. **Results.** Significant differences were found between gamers and non-gamers in both performance and workload. The Mann-Whitney U test revealed that gamers completed the simulated flight tasks in less time (z = -4.168, p < .01) and made fewer errors (z = -4.690, p < .01) compared to non-gamers. Additionally, gamers reported significantly lower workload across all variables measured by the AWT. **Discussion**. The findings suggest that video game experience enhances drone piloting performance and reduces perceived workload. These results have implications for refining training and selection protocols for UAV pilots in both military and civilian contexts. Incorporating gaming-based assessments into the training process could provide a promising avenue to enhance UAV operator capabilities and mission success.

Ventaja Estratégica en el Cielo. Experiencia en Juegos y Eficiencia Operativa: Revelando la Menor Carga de Trabajo Percibida y los Posibles Beneficios de los Jugadores Como Pilotos de Drones

Palabras clave:
Vehículo aéreo no tripulado
Carga de trabajo
Drones
Simulador de vuelo
Factor humano
Videojuegos

RESUMEN

Introducción. Los vehículos aéreos no tripulados (UAV) desempeñan un papel crucial en operaciones militares y civiles modernas, exigiendo un rendimiento cognitivo óptimo de sus pilotos. Los pilotos de drones suelen experimentar lapsos de atención y disminuciones en el rendimiento, lo que puede poner en peligro el éxito de las misiones, la ejecución de tareas y su bienestar. Las investigaciones existentes muestran que los jugadores de videojuegos superan a los no jugadores en ciertas habilidades cognitivas, como el seguimiento visual, la atención y la rotación mental. Este estudio explora cómo la experiencia en videojuegos puede moldear las habilidades y la percepción de la carga de trabajo de los posibles pilotos de UAV. **Método.** Se llevó a cabo un estudio piloto con dos grupos: jugadores de videojuegos (n = 22) y no jugadores (n = 29). Los participantes realizaron tareas simuladas de vuelo de drones utilizando un *Phantom 3* en el simulador *Aerosim RC*. El rendimiento y la carga de trabajo

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se evaluaron mediante el AWT, una prueba derivada del NASA-TLX. **Resultados.** Se encontraron diferencias significativas entre los jugadores y los no jugadores en el rendimiento y la carga de trabajo. La prueba U de Mann-Whitney reveló que los jugadores completaron las tareas simuladas de vuelo en menos tiempo (z = -4.168, p < 0.01) y cometieron menos errores (z = -4.690, p< 0.01) en comparación con los no jugadores. Además, los jugadores reportaron una carga de trabajo significativamente menor en todas las variables medidas por el AWT. **Discusión.** Los resultados sugieren que la experiencia en videojuegos mejora el rendimiento en el pilotaje de drones y reduce la carga de trabajo percibida. Estos hallazgos tienen implicaciones para la mejora de los protocolos de formación y selección de pilotos de UAV en contextos tanto militares como civiles. La integración de evaluaciones basadas en videojuegos en el proceso de formación podría ser una vía prometedora para optimizar las capacidades de los operadores de UAV y garantizar el éxito de las misiones.

Introduction

Unmanned Aerial Vehicles (UAVs) have gained great popularity in recent years, with several contributing factors. On the one hand, technological improvements such as the miniaturization of electromechanical components (Mazur et al., 2016) have facilitated their use. Conversely, the decrease in their price due in part to the lower cost of batteries has enabled more civilians to have access to these systems that until recently were limited to military/security domains.

Currently, the UAVs that have gained the most popularity are those with rotary wings, which vary in the number of rotors they have, ranging from a single rotor (helicopter) to four rotors (quadcopter), and so on. Less common configurations may present 12 or even 16 rotors. These vehicles have a weight that can range between 2 kg. and 25 kg. and are controlled by a transmitter like those used in radio-controlled vehicles. One flight option is first-person view (FPV) mode. In this type of flight, the pilot needs to wear glasses with which they can see live video captured by the drone's camera. This flight mode produces the sensation of being mounted in the vehicle itself, offering a better view to the pilot. This flight mode is mainly used by drone racing pilots (Pfeiffer & Scaramuzza, 2021).

UAVs offer, at a much lower cost, the same advantages as a conventional helicopter, such as a low altitude flight capability, a vertical takeoff and landing, as well as access to remote areas. This evolution, together with the changes in the current regulations, open up more possibilities for using UAVs in different fields and work environments, such as agriculture (Barreiro-Elorza & Valero-Ubierna, 2014; Meneses et al., 2015), architecture (Pacheco, 2017), security (Gomis Balestreri & Falck, 2015), topography (Ferreira & Aira, 2017), and geology.

In the military context, the war in Ukraine has marked a "before and after" in the use of drones, although it is true there were precedents (Bunker et al., 2015) -in Ukraine there had been an escalation in the use of commercial drones for military use. Chulilla (2022) called them "lethal commercial drones." The author was referring to drones of less than 25 kg. developed outside the military sphere by groups of civilians or isolated individuals to be used as weapons. Due to their low cost and the ease of acquiring components to develop them, the use of lethal civilian drones (Chulilla, 2022) has become a common practice since they can be used to launch ammunition, locate targets, direct artillery fire, etcetera.

The development of these aerial vehicles has evolved quickly. However, although much attention has been paid to the development of the hardware of the systems and their technical capabilities, less attention has been paid to creating the human–system interfaces and operator training requirements to control these devices, thus neglecting the human factor of this mixed team system (i.e., human pilot and robot UAV).

Improvements in the durability of batteries and motors (Annati & O'Brien, 2012; Berradi et al., 2016; Harmon et al., 2006) have made it possible for these vehicles' flight autonomy to increase from 12-30 min to several hr (Hispaviación, 2020). This aspect represents a positive advance in the technical domain regarding time and costs (i.e., a decrement in both the number of batteries needed and task completion time by not having to stop work to recharge them).

When piloting, the operators may suffer decrements in their attention and performance capabilities, which may lead, in the long run, to errors. This could affect not only the integrity of the drone or UAV itself but also the task performance and pilot's health. Therefore, it is interesting and necessary to study these human performance variables further, including piloting skills, workload perception, and/or mood status (among other variables) during training to better prepare pilots for real flight missions.-

Because of the operativity and interface characteristics of mixed human/drone configurations in training, video games and simulators have attracted the attention of researchers in the field, especially for their possible enhancement of the performance effect (Devlin & Riggs, 2018; Lin et al., 2015; McKinley et al., 2009; McKinley et al., 2011; Schuster et al., 2008). In the present study we wanted to test possible differentiating aspects in subjects who had previous experience in video games versus subjects who did not when piloting a quadcopter. It is well known that psychologists are increasingly using video games to examine cognition (Bavelier et al., 2012), learning skills (De Araujo et al., 2016), retention skills (Boot et al., 2011), transfer skills (Baniqued et al., 2013), and brain plasticity (Betker et al., 2006).

Previous research shows that video game players (gamers) have higher performance rates than non-gamers in some cognitive abilities, tracking more objectives in visual tasks (Castel et al., 2005; Dobrowolski et al., 2015) and demonstrating better spatial and attentional skills (Dorval & Pépin, 1986; Schubert et al., 2015; Spence & Feng, 2010), psychomotor skills (Griffith et al., 1983), improved efficiency in mental rotation (Boot et al., 2008), improvement in the capacity of the visual attention system (Green & Bavelier, 2003), and better visuomotor coordination, faster processing speed, and a better working memory (Bonny et al., 2016; Spence & Feng, 2010). There is also some evidence that gamers require less time for training (Schmidt et al., 2012). Compared to non-gamers, gamers have also shown better tolerance to fatigue (Lin et al., 2015). All this research suggests that the skills acquired through videogaming can be transferable to other cognitive tasks and environments (Basak et al., 2008; Frederiksen & White, 1989; Gopher et al., 1994; Green & Bavelier, 2007).

Comparative studies between gamers and non-gamers, as well as the abilities' capabilities to transfer to other areas of performance have increased research interest as to how experience in video games translates into enhanced performance in real-world situations, including piloting UAVs (Devlin & Riggs, 2018; Lin et al., 2015; McKinley et al., 2009; McKinley et al., 2011; Schuster et al., 2008). McKinley et al. (2009, 2011), using a Predator Drone simulator, compared the results between pilots, gamers, and a control group. They observed that gamers obtained better results than pilots in those tasks that required the monitoring of multiple objectives and quick responses, as well as in motion inference tasks, or those that refer to the ability to perceive and process both the movement of an object and the estimated trend information to predict its position at a future point in time, even when a direct line of sight cannot be continuously maintained. Aircraft pilots are known to show high skills that are directly relevant to multitasking and attentional shifts, since it is necessary to attend to various stimuli such as lights, sounds, radio, etcetera. However, this is not so clear in UAV piloting, including the piloting of aerial vehicles such as the *MQ1 Predators*. The results from McKinley et al. (2009, 2011) indicate that playing video games may improve and refine general piloting skills, which could benefit both existing pilots and any future pilots. Nevertheless, results from the experiments of McKinley et al. showed that video game players (VGPs) exhibit superior performance in identifying, finding, and tracking visual targets. These results provide further evidence that VGPs may be better suited as sensor operators for UAV missions.

While previous studies have compared gamers to non-gamers in cognitive skills, not many studies have compared flight skills in either real environments or simulations. Schuster et al. (2008) carried out a study where they intended to explain previous findings and found a positive relationship between the experience of video games and the effectiveness of planning/executing routes in a joint simulation of air and ground vehicles. Lin et al. (2015) carried out a study in which simulation areas were designed to represent the demands of cognitive tasks foreseen for a single operator supervising multiple highly autonomous vehicles or drone swarms, incorporating variations of workload and automation levels, to test associations that were generalized across different task settings. The simulation by Devlin and Riggs (2018) was based on the Vigilant Spirit Control Station, a platform interface developed for multiple UAV command and control missions. The participants were responsible for simultaneously managing up to 16 UAVs.

Among the tasks carried out while piloting a UAV are both those related to surveillance and those related to vehicle handling. Both tasks require the ability to maintain attention and remain alert for an extended period (Körber et al., 2015; Meuter & Lacherez, 2016). These surveillance tasks will also be affected by different levels of workload. Workload is defined as the combination of the demand for labor and the human response to this demand (Mouloua et al., 2001). The evaluation of workload is a key point in the research and development of human–machine communication systems to guarantee the long-term safety, health, comfort, and productive efficiency of the operator (Rubio et al., 2004). Prolonged periods of high workload can result in reduced attention, increased tension and fatigue, and a reduced flexibility and comprehensiveness of information processing (Connors et al., 1984; De La Torre et al., 2014; Hockey et al., 1993; Noel et al., 2005; Wanyan et al., 2014). Simultaneously, high physical and mental demands can cause more errors due to increased fatigue and loss of concentration, while concurrent high physical and mental demands can cause additional errors due to increased fatigue and loss of concentration, reducing a human's ability to detect anomalous information, causing longer reaction times (Schuster et al., 2008; Wanyan et al., 2018; Weinger et al., 1994).

Many factors can affect perceived workload: mental, physical, and temporal demand, as well as the general performance and levels of frustration and effort (Evans & Fendley, 2017). High levels of workload may affect human performance, and this situation can be especially dangerous for the success of piloting missions (Moray, 2013).

Therefore, considering how the maximum flight time of UAVs has recently increased due to advances in technology, the study of the workload impact variable has now become more relevant. In a previous study, evaluating the workload factor in simulated flight tests with quadcopter drones, De la Torre et al. (2016) found that those pilots who showed a lower perceived workload during the test had better results than those who scored higher. Devlin and Riggs (2018) studied workload transfer in subjects performing different simulated tasks on a platform that the U.S. Air Force uses to develop interfaces for multiple UAV command and control missions. They developed two types of tasks where they manipulated the workload (low, high, gradual, versus sudden workload), varying the number of UAVs active simultaneously in a target detection task, and they found no differences between gamers and non-gamers during load transitions.

The perception of workload varies among individuals based on their learning skills and their ability to tackle and complete a particular task. Workload can be assessed in three different ways: using performance measures, physiological measures, or via subjective measures (Wilson & Sharples, 2015). The latter are the easiest to use; they help identify the specific sources of demand required by a particular task and are capable of revealing differences in workload between individuals with the same performance score. Haga clic o pulse aquí para escribir texto.The Cooper-Harper Scale represents a good example of a subjective workload perception test (Cooper & Harper, 1969), along with the Bedford Scale (Roscoe, 1984), and finally the NASA-TLX (Hart & Staveland, 1988). The NASA-TLX has been one of the most used tests to measure workload perception. It was translated into more than 12 languages, can be administered both verbally or by computer, and has shown good sensitivity (Hart, 2006). A variant of this test, the Axon Workload Test, was used by De la Torre et al. (2016) to study workload perception when piloting a quadcopter drone, observing how those pilots with a higher workload perception score demonstrated a relatively greater number of errors.

In this study, we evaluated and compared workload perception and tasks performance and effectiveness in a drone flight simulator between gamers and non-gamers.

This was a novel study, since there was little prior research in the literature evaluating the performance of humans when piloting small drones. The bulk of the previous research focused on studies in military and specific capability contexts. Overall, the speed at which the technology of vehicles develops makes it necessary to publish relevant research (Nisser & Westin, 2006). The war in Ukraine has shown how quadcopters can be highly effective. Given the scenario where drones are revolutionizing warfare and also civilian applications, a better understanding of personal variables and training skills are crucial.

Methods

Participants

A total of 51 volunteers participated in this study. The mean age was 26.16 years (*SD* = 7.575). Of the total participants, 31.4% were female and 68.6% male.

All participants were asked about the time they spent playing video games during the week on a scale that included: 0 hr a week (48.14%), less than 5 hr a week (11.11%), and more than 5 hr a week (40.74%). Johannes et al. (2021) and Williams et al. (2008) carried out research to try to offer a profile of VGPs. In their jobs, players spent 4.5-5 hr per week in these environments. For this reason, in the present study, participants who played 5 hr a week or more were included in the group of gamers. The group of non-gamers included those who had no or less than 5 hours of gaming experience per week.

The sample was made up of 43.1% who had previous experience in video games (gamers) and 56.9% who had no such experience (non-gamers). Regarding gaming preferences in the group of gamers, 40.9% used a controller to play games, 4.5% used a keyboard, 50% used a variety of devices, and 4.5% used other types of devices or controllers. The group of gamers was also asked about their preference for type of game. It was observed that 86.4% of the participants played various types of games compared to 4.5% who played shooters, another 4.5% enjoyed role-playing games, and 4.5% selected other types of games those proposed (i.e., action, strategy, shooting, role-playing, simulation, sports). In our study, this variable was not taken into consideration.

It was also required that all participants had good physical and mental health with no history of illness or health problems during the last 6 months. Another inclusion criterion was that they could not have experience handling drones. All testing was performed according to Declaration of Helsinki ethics and protocols. Informed consent was provided by individual respondents and participation was voluntary. All the gathered data were secured, and the privacy chain was protected at every step. In the same way, we were guided by the European Code of Conduct to ensure the integrity of the investigation.

Materials

The *AeroSIM RC©* virtual pilot training system for the Windows platforms (Figure 1) was used for the experiment's drone flight simulator. We used a Phantom activated GPS quadcopter model option operated by a real handheld radio controller. All participants completed the training program, which comprised 24 different tests encompassing five areas: gas (managing the lifting power of the aircraft), translation (omnidirectional movement), stationary (maintaining the craft's position and altitude), toward or forward (stabilizing the aircraft), and landing (Table 1). The radio station used was a DX5e Spektrum 2.4 GHz.

Table 1

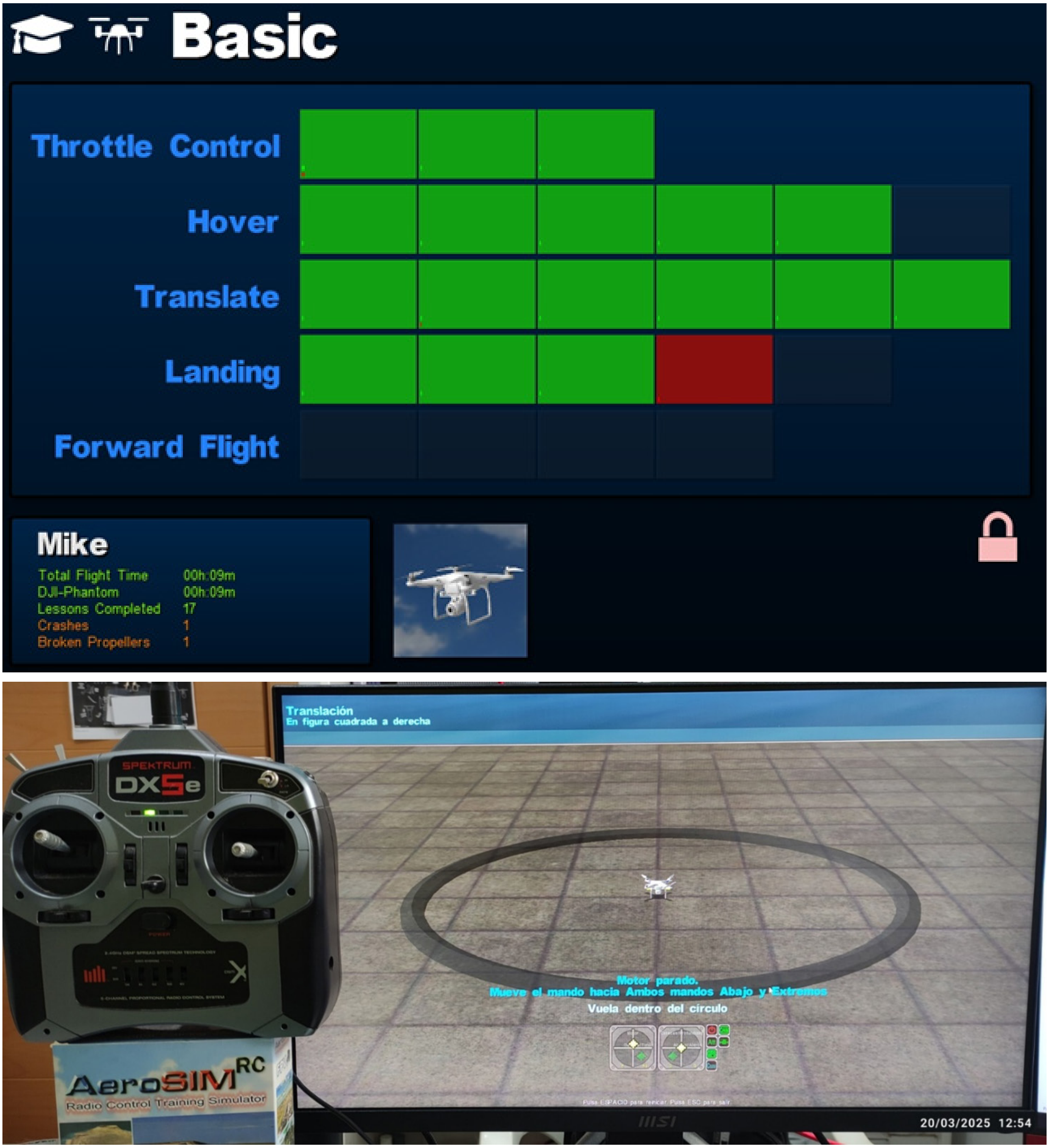
Piloting Skills: Tests That Make up the AeroSIM Tutorial

1. G1: Gas level 1 (A)	13. EMD: Stationary Looking Right (B)
2. EAC: Frozen Altitude Stationary (B)	14. AL: Side landing (D)
3. TLAC: Lateral translation with frozen altitude (C)	15. AFCI: Left square figure landing (D)
4. G2: Gas level 2 (A)	16. AFCD: Right square figure landing (D)
5. EC: Tile Stationary (B)	17. EMO: Morro Stationary (B)
6. TL: Lateral translation (B)	18. AFDI: Left diagonal figure landing (D)
7. G3: Gas level 3 (A)	19. AFDD: Right diagonal figure landing (D)
8. TFCI: Translation in left square figure (C)	20. HFCI: Forward Left Square Figure (E)
9. TFCD: Translation in right square figure (C)	21. HFCD: Forward right square figure (E)
10. EMI: Stationary Looking Left (B)	22. EP: Precision Stationary (B)
11. TFDI: Translation in left diagonal figure (C)	23. HFDD: Forward right diagonal figure (E)
12. TFDD: Translation in right diagonal figure (C)	24. HFDI: Forward left diagonal figure (E)

Note. Letters indicate the five areas of the training tasks in the flight simulator software AeroSIM RC ©: A: gas; B: stationary; C: translation; D: landing; E: forward.

Figure 1

Screenshots of the AeroSIM Simulator and DX5e Spektrum 2.4 GHz



Note. Results summary screen (top). Image of the transmitter and translation test (bottom) Image credits: *AeroSIM RC©.*

In this research we studied two components for the simulator piloting task: piloting skills and workload perception of all participants.

For the workload perception assessment, we used the Axon Workload Test (AWT), adapted from NASA-TLX software (De la Torre et al., 2016; Hart & Staveland, 1988). The NASA-TLX test is a multidimensional assessment procedure that gives an overall workload score based on a weighted average of the scores on six subscales: Physical Demand (PD), Time Demand (TD), Effort (EF), Performance (PF), Mental Demand (MD), and Level of Frustration (FR). The test consists of two parts: scores (ratings) and weights. Participants obtain a score on each subscale after completion of the task. A numerical score in the range of 0–100 is assigned to each subscale. Participants determine the weighting by selecting the workload subscale most relevant to them from a couple of options. The weighting is calculated from 15 pairs of combinations created from the six subscales. The test was reverse-translated by language experts in order to be effective for Spanish-speaking participants, and the subscale PD was modified to fit the specific type of task that participants would be performing in the virtual simulation (Cao et al., 2009).

Piloting skills: When a participant finished the training program, the errors made in each of the 24 tests were displayed on a screen, as well as the total time spent. The errors could be due to not having completed the exercise in the time provided by the simulator or to having crashed the drone. The software made no distinction in the type of error, so all errors were counted in the same way.

Procedure

First, a brief training session was offered for basic concepts of the operation of the transmitter controller to pilot the drone, as well as the basic operating instructions and procedures for using the software. Afterwards, the participants had 2 min to do a free flight test to experience the operation basics of the simulator and solve any doubts they might have. After this basic training session, the flight simulator tests started.

Once all the simulator tests were completed, the total number of errors made, total time, as well as the errors made in each of the five test areas of the simulator were recorded as described in the previous section. Finally, all participants had to complete the AWT (workload test). In Table 2 one can see the order of the tests completed by each participant.

Table 2

Timeline of the Experiment per Subject

FLIGHT PHASE	**BRIEF TRAINING** Instructions and basic use of flight controls (10 minutes) **FREE FLIGHT** Free flight practice (2 minutes) **FLIGHT** Aerosim simulator flight tests (see table 1) (Time to completion recorded)
PSYCHOLOGICAL TESTING	**AWT** <15 minutes after flight

Results

Table 3 shows descriptive data for each AeroSIM RC © test. We observed how gamers made fewer errors in all the simulator tests compared to non-gamers (M = 27.64, SD = 13.944). The total errors index was also lower for the gamers (M = 63.52, SD = 47.053). The gamers also spent less time (M = 27.64, SD = 13.944) completing tests than the non-gamers (M = 56.45, SD = 33.256).

Table 3

AeroSIM RC © Tests Performance: Descriptive Data for Both Groups (Gamers and Non- Gamers)

	Gamers (n = 22)		No-gamers (n = 29)		Total (n = 51)	
Test	***M***	***DE***	***M***	***DE***	***M***	***DE***
Gas	0.180	0.664	2.900	4.499	1.730	3.656
Stationary	0.180	0.501	0.930	1.132	0.610	0.981
Translation	0.820	1.651	4.240	7.693	2.760	6.101
Landing	9.090	10.080	37.000	29.547	24.960	26.953
Forward	5.410	9.179	18.450	16.385	12.820	15.109
Total errors	27.640	13.944	63.520	47.053	42.840	44.560
Time	27.640	13.944	56.450	33.256	44.020	30.145

Note. Total errors: sum of all errors in each of the areas; Time: minutes spent completing the simulator.

A comparative analysis was carried out with a non-parametric test after Shapiro-Wilk normality testing. Mann-Whitney U test statistics showed (Table 4) that the gamer group spent less time completing all tasks (z = -4.168, p < .01) and made a lower number of total errors than the non-gamers group (z = -4.690, p < .01). Specifically, the gamers made fewer errors in hovering flight (z = -4.654, p < .01) and during the gas test (z = -2.996, p < .05), the landing test (z = -4.550, p < .01), the forward test (z = -3.197, p < .05), and the translation test (z = -2.802, p < .05).

Table 4

Mann-Whitney U Test Results From the AeroSIM RC Test for Both Groups (Gamers and Non- Gamers)

	Mean Rank			
Test	No Gamer (n = 29)	Gamer (n =22)	u	p
Time	33.550	16.050	100.00	<.01
Stationary	33.810	15.700	183.500	<.01
Gas	30.670	19.840	92.500	<.05
Translation	30.790	19.680	180.000	<.05
Landing	34.240	15.140	80.000	<.01
Forward	31.780	18.390	151.500	<.01
Total errors	34.500	14.800	72.500	<.01

Note. Total errors: sum of all errors in each of the areas; Time: minutes spent completing the simulator.

The next step was to focus on the workload scores measured by the AWT. First, in Table 5 we can see the descriptive data for the results. We observed significant differences between the two groups. In all cases, the mean scores were lower in the gamers group except on the PD scale, where the gamers scored slightly higher (M = 25.24, SD = 20.278) compared to the non-gamers (M = 25, SD = 22.127).

Table 5

AWT Mean Scores for Both Groups (Gamers vs. Non-Gamers)

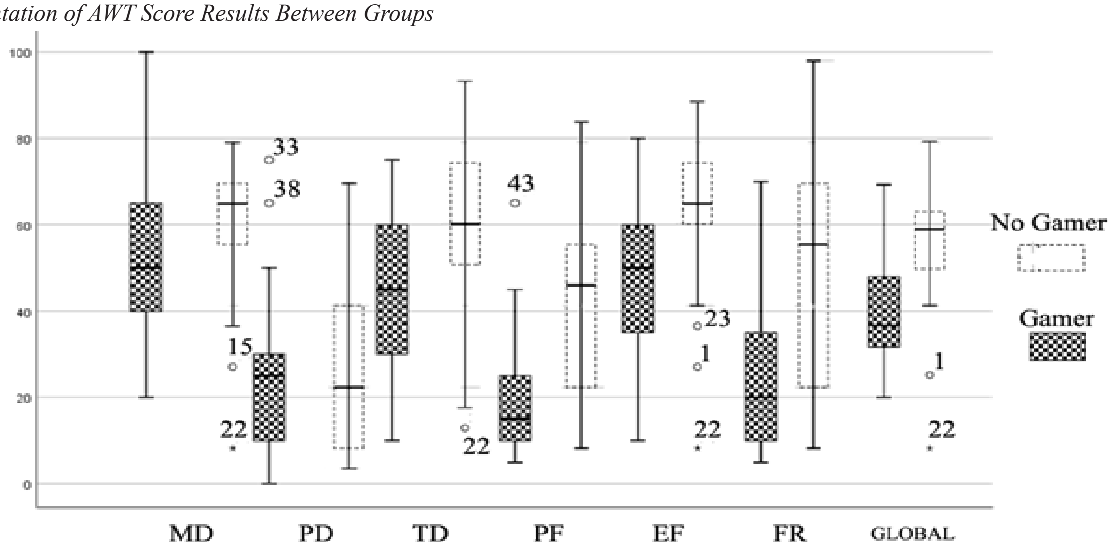
	No Gamer (29)		Gamer (22)	
AWT	*M*	*DE*	*M*	*DE*
MD	59.600	17.965	52.380	20.653
PD	25.000	22.127	25.240	20.278
TD	58.200	23.974	43.810	18.433
PF	40.600	22.047	20.950	14.545
EF	62.600	20.058	46.900	21.005
FR	48.800	29.520	25.950	21.250
SCORE	54.8880	16.260	39.6670	11.935

Note. The six subscales: MD: Mental Demand; PD: Physical Demand; TD: Time Demand; PF: Performance; EF: Effort; FR: Frustration Level; SCORE: Global value for workload perception during the task. (n) = participants.

We also analyzed whether the differences between the two groups were significant. The Mann-Whitney U test statistic was used for this purpose. Figure 2 contains the representation of the AWT scores per group.

Figure 2

Representation of AWT Score Results Between Groups



Note. MD: Mental Demand; PD: Physical Demand; TD: Time Demand; PF: Performance; EF: Effort; FR: Frustration Level; SCORE: Global value for workload perception during the task.

Significant differences were observed between the two study groups for each of the variables measured by the AWT. The gamers had lower scores than the non-gamers in temporal demand (z = -2.090, $p < .05$), PF (z = -3.659, $p < .01$), FR (z = -2.416, $p < .05$), and on the overall AWT score (z = -3.695, $p < .01$) and EF scale (z = -1.965, $p < .05$).

Given the differences observed between both groups per levels of workload and number of errors during the flight simulator tests, we decided to analyze whether there was any relationship between workload and number of errors. For this purpose, we carried out a Spearman correlation test between the different variables (Table 6). We found positive and statistically significant correlations between TD and several of the AeroSIM tests, including simulator time (r_s = .361, $p < .01$), landing tests (r_s = .296, $p < .05$), forward (r_s = .292, $p < .05$), and the number of total errors (r_s = .310, $p < .05$). The PF score was correlated to the simulator tests' translation (r_s = .462, $p < .01$), landing (r_s = .613, $p < .01$), forward (r_s = .523, $p < .01$), total number of errors (r_s = .310, $p < .01$), and total time (r_s = .641, $p < .01$). EF also correlated with gas testing (r_s = .314, $p < .05$), translation (r_s = .409, $p < .01$), forward testing (r_s = .289, $p < .05$), total number of errors (r_s = .277, $p < .05$), and time spent in the simulator (r_s = .302, $p < .05$).

Relationships were also found between FR and the gas test (r_s = .360, $p < .05$), hover test (r_s = .293, $p < .05$), translation test (r_s = .306, $p < .05$), forward test (r_s = .356, $p < .05$), total number of errors (r_s = .347, $p < .05$), and total time in the simulator (r_s = .360, $p < .01$). Finally, statistically significant relationships were also observed between overall AWT scores and the gas test (r_s = .505, $p < .01$), stationary (r_s = .314, $p < .05$), translation (r_s = .530, $p < .01$), forward (r_s = .547, $p < .01$), landing (r_s = .554, $p < .01$), total errors (r_s = .606, $p < .01$), and total time (r_s = .624, $p < .01$) scores.

Table 6

Spearman Correlations Between AWT Variables and AeroSIM RC Test

	MD	PD	TD	PF	EF	FR	SCORE	Time	GAS	Station.	Transl.	Landing	Forward
MD	1.000												
PD	0.080	1.000											
TD	0.129	0.148	1.000										
PF	0.224	-0.011	.427**	1.000									
EF	.541**	.326*	.332*	0.267	1.000								
FR	0.274	.310*	.620**	.462**	.402**	1.000							
SCORE	.609**	0.214	.761**	.738**	.666**	.758**	1.000						
Time	0.223	0.023	.371**	.641**	.302*	.360**	.624**	1.000					
GAS	0.179	0.143	0.258	.517**	.314*	.348*	.505**	.636**	1.000				
Stationary	0.106	-0.060	0.024	0.225	0.129	.293*	.314*	.376**	0.165	1.000			
Translation	0.211	0.177	.361**	.462**	.409**	.306*	.530**	.745**	.567**	0.208	1.000		
Landing	0.270	-0.004	.296*	.613**	0.260	0.250	.554**	.901**	.631**	.383**	.649**	1.000	
Forward	0.231	0.154	.292*	.523**	.289*	.356*	.547**	.823**	.457**	.389**	.664**	.673**	1.000
Total errors	0.255	0.044	.310*	.627**	.277*	.347*	.606**	.959**	.657**	.465**	.722**	.947**	.826**

** The correlation is significant at the level 0.01 (bilateral). * The correlation is significant at the level 0.05 (bilateral).

Note. MD: Mental Demand; PD: Physical Demand; TD: Time Demand; PF: Performance; EF: Effort; FR: Frustration Level; SCORE: Global value for workload perception during the task. Flight simulator tests: Gas: G1, G2, G3; Stationary: EAC, EC, EMI, EMD, EMO, EP; Translation: TLAC, TL, TFCI, TFCD, TFDI, TFDD; Landing: AL, AFCI, AFCD, AFDI, AFDD; Forward: HFCI, HFCD, HFDD, HFDI; Total Errors: the sum of errors on all tests; Time: the total time spent completing the training program.

Discussion

Existing research indicates that gamers might have skills that favor drone piloting, hence the importance of continuing with these lines of research (Devlin & Riggs, 2018; Lin et al., 2015; McKinley et al., 2009; McKinley et al., 2011; Schuster et al., 2008). In addition to some advantages shown in the scores from cognitive skills testing for VGPs (video game players), the fact that the ergonomic and physical characteristics of drone piloting controls are very similar to those used in flight simulator video games suggests possible transfers of skills and benefits. Billings and Durlach (2008) observed how flight simulation missions were completed more quickly when the subjects used a gamepad instead of a mouse, and the same effect for touch screens versus gamepads has been described (Durlach et al., 2006). These results continue to support the idea of possible advantages of gamers versus non-gamers for piloting UAVs. In our study, most participants used controllers to play, so we were unable to verify this fact.

We observed how the gamers showed a superior performance on all the simulator tests, which allowed them to finish the exercise earlier and make a fewer number of total errors than the non-gamers. These results cohere with previous research by Schmidt et al. (2012), who found that gamers required less time for training. We can imagine that the skills acquired through video games could be transferred to other environments, as previous studies have demonstrated (Basak et al., 2008; Frederiksen & White, 1989; Gopher et al., 1994; Green & Bavelier, 2007).

The workload perception results differed according to MD (mental demand), PF (performance), EF (effort), and FR (level of frustration), and the global scale results reflected lower scores for the gamers group. De la Torre et al. (2016) demonstrated how a higher MD score can correlate with more errors in flight simulators. In our study, some workload indices (time demand, performance, effort, frustration, and global workload perception) correlated with the total time spent in the simulator and the total number of errors made. Thus, the results in our simulated drone flight task were affected by mental load. In this study, and in line with Lin et al. (2015), we can see how gamers can perceive a lower workload and achieve better results in flight tests, probably confirming that gamers have a better tolerance to fatigue.

Overall, our sample size and specificity (the type of preferred game) of the gamers group represents limitations of this study and a challenge for future research. Still, it is necessary to continue studying how humans interact with UAVs to better understand which emotional, cognitive, or personality variables influence piloting skills. This is increasingly relevant as UAV systems and UAV swarms are currently reaching more complex configurations and autonomous capabilities. Human performance-related information will allow us to create better focused training programs and help in selecting people who have the best skills and characteristics for piloting UAVs, saving time, effort, and maximizing performance.

Author Contribution Statement

Miguel A. Ramallo-Luna: design of the work, writing, data analysis and the interpretation of the results.

Sara Gonzalez-Torre: acquisition of data and analysis.

Jose Manuel Nuñez-Molleda: data acquisition and handling.

Gabriel G. De la Torre: design of the structure of the study and writing the Introduction.

All the authors present here show their responsibility in all aspects of the work.

Author Disclosure Statement

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