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Empirical study on Game Transfer Phenomena in a location-based augmented reality game

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ABSTRACT

Research on Game Transfer Phenomena (GTP) has demonstrated that playing video games can lead to re-experiencing images, sounds, tactile sensations, spontaneous thoughts and actions, sometimes triggered by physical objects/events associated with the game. Location-based augmented reality games posit interesting questions regarding GTP, particularly because they use physical locations, they overlay digital images in physical contexts and the gameplay shifts between the virtual and the physical world. This study aims to investigate the prevalence of GTP and the role of immersion, augmented reality and sound in a sample of English- (EnS) and Spanish- (SpS) speaking gamers of the game *Pokémon Go* (PoGo). A total of 1313 gamers (M_{age} = 31.47) were recruited online. GTP was less common than in previous studies; however, 82.4% had experienced GTP at least once. The SpS showed higher prevalence of GTP and played more intensively. Automatic mental processes predominated in the EnS, while behaviours and actions were more common in the SpS. The absence or presence of video game features seems important for the way GTP manifests. For instance, tactile hallucinations were more prevalent, while sensations of self-motion were less reported. Playing with augmented reality (AR) and sounds showed significant correlations with various GTP types, but not with re-experiencing images from the game. More gamers who reported the sensation that Pokémon were physically present or looked for Pokémon outside the screen while playing, as connotations of immersion, had experienced GTP. Experiencing GTP while playing may be more common in location-based augmented reality games, compared to other games.

1. Introduction

"I saw a pigeon standing on the street and had a momentary urge to throw something at it [to capture it]."

"A fire truck was coming down the street, and there was a Pokémon spawned [appeared] in the street. I thought… 'I hope the fire truck doesn't hit the Meowth [Pokémon]'. And then I realized what a strange thought that was."

The ways of playing video games are in constant evolution; and the tendency is to make video games more accessible, enjoyable and immersive (Deterding et al., 2011). Location-based augmented reality mobile games use a real-time generated map of the actual physical world around the player (supported by GPS technology and the camera of the device). These games overlay digital images on

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Fig. 1. Comparison of Pokémon Go with the AR function on and off (Trinnah, n.d.).

physical world contexts that are captured through the mobile device camera (Werner, 2017). The location-based augmented reality mobile game *Pokémon Go* (PoGo) (Niantic, 2016) is one of the first of its kind and can be played with the augmented reality (AR) function turned on or off. The gameplay in PoGo consists of capturing Pokémon (small creatures), finding items at "PokeStops" (i.e., a "stop" or station related to Pokémon) that can be used, for example, when capturing Pokémon, and holding/fighting for "gyms" (Tabacchi et al., 2017).

Research into Game Transfer Phenomena (GTP) has demonstrated that playing video games can lead to re-experiencing, at least temporary images, sounds, tactile sensations, spontaneous thoughts and actions, sometimes triggered by physical objects/events associated with the game. GTP has been reported with both new and old video games, in over 400 unique titles (Ortiz de Gortari, 2016a) and even in the PoGo predecessor, the location-based augmented reality game (Sifonis, 2016) *Ingress* (Niantic, 2013). Most gamers have experienced GTP at least at some point in their life, and most have experienced GTP more than once and/or several types (Ortiz de Gortari and Griffiths, 2016; Ortiz de Gortari et al., 2016).

Location-based augmented reality mobile games posit interesting questions regarding GTP. The most important factors are: i) overlaying of images in physical contexts, ii) location where the game is played, iii) shifting between modes, and iv) using or not using features of the game.

Overlaying of images in physical contexts via the augmented reality feature: Studies about GTP have shown that gamers experience hallucinatory-like phenomena in various sensory modalities with video game content (e.g., seeing images, hearing sounds, tactile and proprioceptive sensations, misperceptions of real-life objects that share similarities with elements in the game, and perceptual distortions of objects and environments) (Ortiz de Gortari and Griffiths, 2014a). It was therefore interesting to investigate if playing PoGo, which uses AR technology, had some effect on these particular experiences (see Fig. 1).

Location where the game is played: Automatic associations between video game-related elements and physical stimuli are expected when the gameplay requires exploring public locations. GTP tend to occur in day-to-day context (Ortiz de Gortari and Griffiths, 2016), sometimes when triggered by game-related cues (i.e., physical objects or events that have been portrayed or simulated in the game) (Ortiz de Gortari et al., 2011; Ortiz de Gortari and Griffiths, 2014b). For instance, sounds have been heard when passing by an environment similar to one in the game, menus and maps have popped up in the corner of the vision when in conversation, or urges to climb buildings have been reported when seeing buildings that resemble those from the game (see Fig. 2).

Shifting between modes: Playing location-based augmented reality games requires constantly shifting between the virtual and the physical world while exploring physical locations (See Fig. 1). Digital images are overlaid on physical world environments when using the AR function, although the game is anyway viewed on the mobile screen. Most video games played on a console, computer,

Fig. 2. Pokémon Go gameplay in an urban zone and map (Ortiz de Gortari, 2016c).

mobile via a screen or VR headset, may easily lead to sensorial neural adaptations (e.g., motion after-effects) (Dyson, 2010; Ortiz de Gortari and Griffiths, 2014a) since they do not involve shifting modes, the exposure to the video game elements is intermittent and usually for longer periods of time compared to location-based augmented reality mobile games (see Fig. 2).

Moreover, besides the potential, the degree of embodiment in the current location-based augmented reality games is limited in comparison to immersive computer/console games (e.g., feeling virtual entities as a part of the self) (Yee and Bailenson, 2007). The avatar mainly acts as a mediator of the game experience, if there is an avatar at all. Another interesting factor to examine closely related to GTP experiences is the immersion in location-based augmented reality games that may be characterised by cognitive mix-ups while playing, derived from the shifting between the physical and the virtual view and the overlaying of digital images, including to investigate if digital images actually are experienced as being physically present considering the flexibility of locations and places where the images can be overlaid (e.g., body parts) (see Fig. 3). This is in addition to well-known phenomena that denote immersion such as losing track of time and forgetting what is happening around oneself while playing (Ermi and Mäyrä, 2005). The variables investigated in this study in this regard were "looking outside the screen for digital elements" and "feeling that digital elements from the game are present in the physical world".

The features of the game: *i) Visual and auditory cues.* The use of visual and auditory cues implemented so far in most mobile games tend not to be as rich or play as important a role as in games on other platforms (e.g., high definition visual effects, surround sound effects) (Craig, 2013). However, future AR games promise to implement audio cues and aural realism (Shah, 2017). *ii) Touch interface.* Playing games on a smartphone requires the user to be in direct contact with the touch surface of the screen, as well as feeling vibrating outputs and other haptic effects that some games use. This may facilitate re-experiencing tactile sensations/hallucinations after playing. In fact, re-experiencing vibrations from mobile phones have been reported in various studies (Drouin et al., 2012; Lin et al., 2013).

In summary, this paper provide the initial insights to answer the following questions: i) If gamers are seeing images after playing video games (seeing images with open eyes or with closed eyes), misperceiving real-life objects by those in the game, can playing an augmented reality game, that actually overlays digital images on physical contexts facilitate these experiences? ii) could there be a relation between experiencing GTP and feeling that video game characters (in this case Pokémon) are physically present in the real world? iii) if GTP tends to be triggered by physical object simulated in the real world and location-based augmented reality games use the real world as a platform, what is the prevalence of GTP in comparison to playing conventional (non-location-based augmented reality) video games?

This study aims to investigate the prevalence of GTP in a sample of English- and Spanish-speaking gamers that play the location-

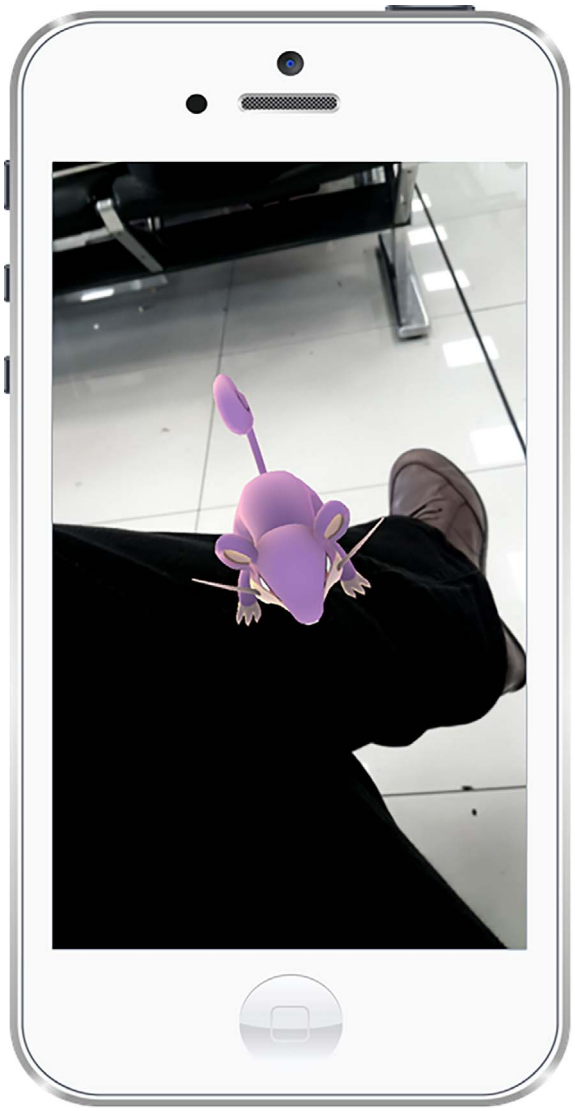

Fig. 3. Pokémon Go image overlaying a person's leg (Ortiz de Gortari, 2016b).

based augmented reality game Pokémon Go (PoGo), to gain insights on the differences and similarities of GTP associated with different gaming platforms. The study also aims to examine the relation between the various forms of GTP, immersion, playing in AR mode and playing with sound.

2. Method

2.1. Participants

A total of 1313 Pokémon Go players answered an online survey either in English (n = 1085) or Spanish (n = 228), (Mean*Age* = 31.47, Sd = 10.03, range 18–87). Almost half of the participants were female (49.4%) and the majority were employed (61.9%). There were fewer students in the English-speaking sample (EnS) (17.2%) than in the Spanish-speaking sample (SpS) (39.1%). In the EnS the most predominant countries of residence were USA (40.4%), Sweden (22.6%), UK (11.7%), Canada (7.8%) and Australia (3.4%). In the SpS (17.4%) they were Mexico (52%), Chile (16%) and Colombia (15%).

2.2. Procedure

This study used a cross-sectional design where two independent data sets were collected using a questionnaire in two languages. An online survey was completed by adult PoGo gamers recruited via online forums and from several Facebook groups about PoGo.

Most Facebook groups had over 500 members, and they were either in English, Spanish or Swedish. The recruitment and the data handling were conducted according to the guidelines of the ethical board of the Norwegian Center for Research Data (NSD). Participants' IP addresses were not collected, and no personal information was obtained. Eligible individuals, those who confirmed that they were 18-years-old or older, proceeded to answer the online questionnaire once they had signed the consent form.

2.3. Measures

Demographics. These items include age, gender, occupation and country of residence.

Game Transfer Phenomena Scale (GTPS). The GTPS comprises a total of 20 items in a 5-point Likert scale of frequency. The scale assesses five dimensions of GTP.

Altered visual perceptions: mind visualisation or seeing video game-related images with closed eyes or open eyes, perceiving real-world objects distorted or misperceiving real-world objects or environments as something from a video game.

Altered auditory perceptions: hearing music, sounds or voices related to video games, perceiving real-world auditory cues distorted or misperceiving them as something from a video game.

Body and other altered perceptions: sensations of self-motion (e.g., fingers, movement of the body), tactile sensations (e.g., pressing the screen, vibrations), body changes (feeling shorter/smaller, etc.) or feeling as if the mind disconnects from the body, perceiving time distorted (e.g., feels like time goes slower or faster after playing), which should not be confused with losing track of time when playing.

Automatic mental processes: urges triggered by associations to perform an action from a video game in situations beyond the game; still being in the mindset of a video game; thoughts about using video game elements in situations beyond the game; source monitoring errors when confusing video game events or characters with those in the real world.

Behaviours and actions: verbal outbursts, involuntary movements of fingers or arms in response to video game-related cues, performing an activity influenced by a video game or unintentionally acting differently due to something experienced while playing.

For this study, the items of the original GTP scale were adapted to PoGo and the examples were modified accordingly in the English and Spanish languages. Examples included: "saw the map, poké balls, or some character from Pokémon Go with my eyes closed", "saw an object or animal in the real world and thought for a moment it was a character from Pokémon Go", "approached landmarks/statues/fountains, etc., expecting to find Pokéballs when not playing", "kept looking for Pokéstops after stopping playing", "heard the Pokéball-shooting sound".

Game Transfer Phenomena with other video games. This was a single question of frequency, to examine if the gamers had experienced GTP with video games other than PoGo.

Gaming habits. Three items were created for measuring the participants' gaming habits and experience of playing video games: i) hours per week playing video games other than PoGo, ii) level of expertise playing video games (beginner, intermediate, advanced, professional), iii) having played Pokémon games before (fan, play at some point, never played them).

PoGo habits. These variables included questions about: i) months playing PoGo, ii) times playing per day, iii) hours playing per week, and iv) session length.

PoGo characteristics. Two questions measured the frequency of playing PoGo with the AR mode and sound activated. An additional question asked what device PoGo was usually played on (mobile phone or tablet).

Levels of immersion while playing PoGo. Four items were created to measure immersion in PoGo using a frequency scale (i.e., never, rarely, sometimes, often, always): i) forget about the surroundings ("When I'm playing I forget what is going on around me"), ii) lose track of time ("I lose track of time when playing Pokémon Go"), iii) mix-ups ("While playing Pokémon Go I make the mistake of starting to look for Pokémon outside the screen"), and iv) have the sensation that a Pokémon was real ("I have the sensation that Pokémon are present in the real world"). The Cronbach's Alpha for these items was 0.683. The Kaiser-Meyer-Olkin measure verified the sampling adequacy for the analysis. KMO = 0.685. All the KMO values for individual items were > 0.766, which is above the acceptable limit of 0.5. The Bartlett's test of sphericity $X^2(6) = 894.246$ $p < .001$, indicates that the relation between the items was sufficiently larger for PCA.

2.4. Data analysis

The first step in the data analysis was to create a new dichotomous variable to measure the prevalence of GTP. The variable labelled "GTP" included all participants who had experienced GTP at least once, independently of the frequency (i.e., "once", "many times", etc.); the label "No_GTP" contained those that had never experienced GTP (i.e., answered "never" to all GTP items). To determine the levels of severity of GTP in the sample, three groups (low, moderate and severe) were created based on 80-points of the GTP scale (Ortiz de Gortari et al., 2016). Initially, the data was analysed in the full population and then across the two sub-samples. Following the analysis of descriptive statistics, chi-square tests and Pearson's correlation coefficients were conducted to examine the prevalence of GTP in the full population and in the sub-samples, and the association between GTP, immersion and PoGo features. Additional analyses were conducted to obtain insight into the differences in the prevalence of GTP between the sub-samples, and exploratory factor analysis was conducted for creating the measure of immersion in PoGo. Not all participants answered every question, therefore the total sample size may be different in the analysis of different variables.

3. Results

3.1. Gaming habits

Most of the participants had played Pokémon games before. Some were fans of Pokémon (42.4%), and some had played Pokémon games before at some point (23.9%). Most of the participants had played video games other than PoGo (88.3%). Most of the participants considered themselves intermediate (41.8%) or advanced gamers (40.3%), followed by beginners (12.2%) and professionals (5.7%). The average over the last 12 months for hours playing video games in general per week was 11.9 h (Sd = 16.275, range 0–130). The average hours per week invested exclusively in playing PoGo were 15.06 (Sd = 16.337, range 1–100). Most participants tended to play PoGo 2–3 times per day (45.9%) or > 5 times per day (23.7%). However, a small number also played 0–1 times per day (16.3%) or 4–5 times per day (14.1%). The length of their sessions tended to be 31 to 60 min (37.3%) or < 30 min (30.4%). Another small number of participants played 61 to 90 min (12.8%), 1.5 to 2 h (10.1%) and > 2 h (9.4%). The majority had reached between levels 21 and 30 in PoGo (66.5%) or 31 to 40 (26.1%). Most of the sample (99.1%) played PoGo on a mobile phone rather than on a tablet.

3.2. Prevalence of GTP experiences with Pokémon Go

The prevalence of GTP in the full sample was 82.4%. Regarding the severity of GTP (i.e., frequency and the types of GTP), the majority showed low levels of GTP (96%); other levels were moderate (3.7%) and severe (0.3%). The most prevalent GTP reported were automatic mental processes (64.0%), and altered visual perceptions (50.0%). These were followed by behaviours and actions (46%), altered auditory perceptions (35.7%) and altered body perceptions (27.4%). The most prevalent items of GTP were: i) wanted or felt the urge to do something in real life after seeing something that reminded the gamer of PoGo when he/she was not playing (52.9%), ii) involuntarily sung, shouted, or said something with contents of PoGo (41.3%), iii) visualised or seen images from PoGo with closed eyes (38.8%), iv) still being in the mindset of PoGo (33.2%), v) hearing music from PoGo (24.3%), and vi) feeling tactile sensations as when playing (21.9%) (see Table 1 for the prevalence of different GTP types in PoGo). Those who had experienced GTP with PoGo were significantly more likely also to have experienced GTP with other video games (39% vs 13.9%) (χ^2 [1] = 53.223, p < .001).

3.3. Comparing the prevalence of GTP between the sub-samples

Those in the SpS were significantly less likely to not have experienced GTP (89.5%) compared with those in the EnS (83.5%) (χ^2 (1) = 9.504, $p < .01$). Low levels of severity were found in most participants in both samples (EnS 96.5%, SpS 94.1%). More in the SpS had moderate GTP (SpS 5.4%, EnS 3.3%) and severe GTP (SpS 0.5%, EnS 0.2%). No significant associations were found regarding the levels of severity of GTP in the sub-samples (χ^2 (1) = 2.461, $p > .05$).

Regarding the GTP sub-scales, the prevalence in the EnS was as follows: automatic mental processes (63.4%), altered visual perceptions (50.3%), behaviour and actions (41.1%), altered auditory perceptions (31.9%), altered body and other perceptions (25.7%). In the SpS the prevalence was: behaviour and actions (69.3%), automatic mental processes (66.7%), altered auditory perceptions (53.7%), altered visual perceptions (48.7%), and altered body perceptions (35.1%).

Regarding the sub-scales of GTP, those in the SpS were significantly more likely to have experienced altered body perceptions (EnS 25.7%, SpS 35.1%) (χ^2 (1) = 8.333, $p > .001$), and behaviours and actions (EnS 41.1%, SpS 69.3%) (χ^2 (1) = 60.285, $p > .001$), while those in the EnS were significantly less likely to have experienced altered auditory perceptions (EnS 31.9%, SpS 53.7%) (χ^2 (1) = 39.076, $p > .001$).

A closer examination of the types of GTP showed that the SpS had higher prevalence for most of the GTP types compared to the EnS. Only “still being in the mindset of the game” was less likely to be experienced by the SpS (EnS 34.7%, SpS 26.3%), (χ^2 (1) = 5.906, $p < .001$). Those in the SpS were significantly less likely to not hear music from PoGo (EnS 21%, SpS 39.9%), (χ^2 (1) = 8.110, $p < .001$). Also, those in the SpS were significantly more likely to have experienced seeing PoGo-related images with open eyes (EnS 15.1%, SpS 22.8%), (χ^2 (1) = 8.110, $p < .01$), hearing sounds (EnS 15.4%, SpS 29.4%), (χ^2 (1) = 25.194, $p < .001$) or hearing PoGo-related voices (EnS 10.4%, SpS 18.9%), (χ^2 (1) = 12.834, $p < .001$), having mistaken sounds in the physical world with those from the game (EnS 14.9%, SpS 29.1%),(χ^2 (1) = 26.156, $p < .001$), having illusions of body movement (6.5% EnS, 11.4%), (χ^2 (1) = 6.504, $p < .05$), having tactile sensations (EnS 20.6%, SpS 28.1%), (χ^2 (1) = 6.233, $p < .05$), thinking of using a video game element in the physical world (EnS 16.6%, SpS 30.3%) (χ^2 (1) = 22.921, $p < .001$), making mix-ups between game and physical world events (EnS 7.6%, SpS 25%), (χ^2 (1) = 59.541, $p < .001$), saying, shouting or saying something involuntarily (EnS 36.5%, SpS 64%), (χ^2 (1) = 58.942, $p < .001$), moving arms or fingers involuntarily in response to game-related cues (EnS 4.4%, SpS 7.9%), (χ^2 (1) = 4.754, $p < .05$), and performing an activity influenced by the game (EnS 10.1%, SpS 16.7%), (χ^2 (1) = 6.233, $p < .01$) (see Table 1 for the full results).

Demographics (gender and age) and gaming habits-related variables (hours playing per week, session length and times playing per day) were examined to find possible explanations of the differences in the prevalence of GTP between the sub-samples.

3.4. Demographics, GTP and differences between the sub-samples

No significant associations were found between GTP and gender (male 48.2%, and female 50.6%) (χ^2 (2) = 1.376, $p > .05$).

Table 1
Frequencies and chi-square of GTP sub-scales and items in the full sample and sub-samples.

	Total sample n = 1313	English-speaking n = 1085	Spanish-speaking n = 228	X^2	*d.f.*	*p* value
GTP overall	82.4	80.9	89.6	9.504**	1	.002
I. Altered perceptions overall	64.8	63.2	72.4	6.906**	1	.009
Altered visual perceptions sub-scale	50	50.3	48.7	0.202	1	.653
Visualized/seen PoGo images with closed eyes	38.8	39.2	37.3	0.283	1	.595
Seen PoGo images with my eyes open	16.5	15.1	22.8	8.110**	1	.004
Seen distorted real-life environments and/or objects	8.3	8.2	8.8	0.080	1	.777
Misperceived a real-life object as something from PoGo	19.8	19.4	21.5	0.496	1	.481
Altered body perceptions sub-scale	27.4	25.7	35.1	8.333**	1	.004
Bodily sensations of movement as if I was in a PoGo	7.4	6.5	11.4	6.504	1	.011
Tactile (touch) sensation associated with PoGo	21.9	20.6	28.1	6.233*	1	.013
Perceived body differently after playing PoGo	5.3	5.1	6.6	0.851	1	.356
I have felt as though the mind has disconnected from the body	7.6	7.2	9.6	1.621	1	.203
Altered auditory perceptions sub-scale	35.7	31.9	53.7	39.076***	1	.000
Re-experienced music from PoGo	24.3	21.0	39.9	36.585***	1	.000
Re-experienced sounds from PoGo	17.8	15.4	29.4	25.194***	1	.000
Re-experienced voices from PoGo	11.9	10.4	18.9	12.834***	1	.000
Misinterpreted sound IRL with something from PoGo	17.4	14.9	29.1	26.156***	1	.000
II. Automatic mental processes scale	64.0	63.4	66.7	0.867	1	.352
Wanted or felt the urge to do something in real life triggered by a PoGo-related cue	52.9	53.7	48.7	1.927	1	.165
I have experienced still being in the mindset of PoGo after playing	33.2	34.7	26.3	5.906***	1	.015
Thinking about using something from PoGo when not playing	19	16.6	30.3	22.921***	1	.000
Mixed up PoGo events with actual real-life events	10.7	7.6	25.0	59.541	1	.000
III. Behaviours and actions scale	46.0	41.1	69.3	60.285	1	.000
Sang, shouted or said something from PoGo unintentionally	41.3	36.5	64.0	58.942*	1	.000
Movement of arms or fingers involuntarily in response to a PoGo related cue	5.0	4.4	7.9	4.754*	1	.029
Acted out behaviour or performed an activity influenced by PoGo	11.3	10.1	16.7	8.029**	1	.005
Acted differently in real-life situations because of something experienced in PoGo unintentionally	7.5	7.3	8.3	0.302	1	.583

* $p < .05$.
** $p < .01$.
*** $p < .001$.

However, there were differences in the sub-samples (χ^2 (2) = 93.769, $p < .001$). There were more females in the EnS (EnS 56.5% vs. SpS 23.2%) and in the SpS there were more males (SpS 76.8%, EnS 43.5%). Age was significantly associated with GTP (χ^2 (12) = 28.104, $p > .01$). Those who were 18–21 years old were less likely to not have experienced GTP (6.9% vs 13.7%) and 58–61-year-olds were more likely to not have experienced GTP (2.6% vs. 0.8%). There also were significant differences between the sub-samples regarding age (χ^2 (12) = 104.195, $p > .001$). Those who were 18–21 years old were significantly more likely to be in the SpS (10.4% vs. 25.6%) and significantly less likely to be in the EnS. Moreover, those who were 42–45 years old (6.1% vs. 0.8%), 46–49 years old (5.2% vs. 0.8%), 50–53 years old (3.7% vs. 0.8%), and 54–57 years old (2.9% vs. 0%) were less likely to be in the SpS.

3.5. Gaming habits, GTP and differences between the sub-samples

Hours playing per week were significantly associated with GTP (χ^2 (3) = 7.975, $p < .05$), and differences were found between the sub-samples. Those who played 36 h or more per week were significantly more likely to be from the SpS (EnS 3.6%, SpS 8.2%). Session length was not significantly associated with GTP (χ^2 (2) = 8.456, $p < .05$), but differences were found between the sub-samples. Those who played sessions shorter than 30 min were significantly less likely to be from the SpS (23.5% EnS, 32.2% SpS) and those who played sessions longer than 2 h were significantly more likely to be from the SpS (EnS 8%, SpS 14.5%) (χ^2 (2) = 12.874, $p < .05$). The number of times playing per day was significantly associated with GTP (χ^2 (3) = 9.125, $p > .05$). Those who played 0 to 1 times per day were significantly more likely to not have experienced GTP (23.5% vs. 15.1%). No significant differences were found between the sub-samples (χ^2 (3) = 551, $p < .05$). Those who had PoGo levels of between 1 and 10 (2.7% vs. 0.7%) or 11 and 20 (14.1% vs. 4.1%) were significantly more likely to be in the SpS. Those who had the highest levels, 31 to 40 (16.4% vs. 28.7%), were significantly less likely to be in the SpS compared with the EnS (χ^2 (3) = 43.693, $p < .001$).

Table 2
Chi-square of the use of AR mode and sound and the different GTP sub-scales.

GTP sub-scales	AR					Sound				
	Off n = 18	On n = 178	X^2	*d.f.*	*p* value	Off n = 63	On n = 82	X^2	*d.f.*	*p* value
GTP overall prevalence			2.035	1	.154			1.198	1	.274
Yes	88.5	94.6				90.5	95.1			
No	11.5	5.4				9.5	4.9			
Altered perceptions overall			1.718	1	.190			7.123**	1	.008
Yes	71.3	79.7				68.3	86.6			
No	28.7	20.3				31.7	13.4			
Altered visual perceptions			0.262	1	.609			4.366*	1	.037
Yes	51.6	55.4				46.0	63.4			
No	48.4	44.6				54.0	36.6			
Altered auditory perceptions			3.597	1	.058			11.224**	1	.001
Yes	49.6	63.5				41.3	69.1			
No	50.4	36.5				58.7	30.9			
Altered body perceptions			0.552	1	.457			7.095**	1	.008
Yes	35.2	40.5				27.0	48.8			
No	64.8	59.5				73.0	51.2			
Automatic mental processes			0.317	1	.573			1.481	1	.224
Yes	66.4	70.3				65.1	74.4			
No	33.6	29.7				34.9	25.6			
Behaviours and actions			2.872	1	.090			1.559	1	.212
Yes	65.6	77.0				63.5	73.2			
No	34.4	23.0				36.5	26.8			

*** $p < .001$.
* $p < .05$.
** $p < .01$.

3.6. GTP and PoGo features

Playing PoGo with AR enabled and playing the game with the sound on were investigated exclusively in the SpS (n = 196). Only 37.8% played using the AR mode at some point (n = 196) and more than half played with sound at some point 56.6% (n = 145).

More gamers who played using the AR mode have experienced GTP but using the AR mode was not significantly associated with GTP overall (χ^2 (1) = 2.035, $p < .05$). Nor was playing with the AR mode significantly associated with any of the GTP sub-scales. However, significant associations were found when chi-square tests were conducted with AR and the types of GTP.

Those who played using the AR mode were significantly more likely to i) have misperceived objects (χ^2 (1) = 4.434, $p > .05$), ii) felt the body differently after playing (χ^2 (1) = 4.516, $p > .05$), iii) heard music from the game (χ^2 (1) = 3.889, $p > .05$), iv) heard sounds from the game (χ^2 (1) = 3.844, $p > .05$), or v) misperceived a sound in real life with something from the game (χ^2 (1) = 4.510, $p > .05$).

Playing with sound was significantly associated with most of the GTP sub-scales. Those who played with the sound on were significantly more likely to: have experienced overall altered perceptions (χ^2 (1) = 7.123, $p > .01$), altered visual perceptions (χ^2 (1) = 4.366 $p > .05$), altered auditory perceptions (χ^2 (1) = 11.224 $p > .01$), and altered body perceptions (χ^2 (1) = 7.095 $p > .01$). A closer look at the GTP types showed that those who played with the sound on were significantly more likely to i) have experienced bodily sensations of movement as if playing (χ^2 (1) = 5.243 $p > .05$), ii) felt the body differently after playing (χ^2 (1) = 4.891 $p > 0.05$), heard music (χ^2 (1) = 10.035, $p > .01$), iii) heard sounds (χ^2 (1) = 6.666, $p > .05$), iv) mistaken a sound in real life with some sound from the game (χ^2 (1) = 13.307, $p > .001$), v) have thought about using something from Pokémon Go in real life (χ^2 (1) = 5.326, $p > .05$), vi) mixed up video game events with actual real-life events (χ^2 (1) = 7.167, $p > .01$), and vii) experienced movements of arms or fingers involuntarily in response to a game-related cue (χ^2 (1) = 4.577, $p > .05$) (see Tables 2 and 3 for the full results).

3.7. Immersion

Analysis was conducted with chi-square tests in the full sample with each of the immersion variables (e.g., *looking for Pokémon outside the screen while playing*) since some of the variables used as measures of immersion highlighted the special properties of AR.

Forgetting what is happening around you while playing PoGo was significantly associated with GTP (χ^2 (1) = 52.305, p < .001). Those who did not forget what was going on around them were less likely to have experienced GTP (71.8% vs 88.3%) and those who did forget were less likely to not have experienced GTP (11.7% vs 28.2).

Losing track of time while playing PoGo was significantly associated with GTP (χ^2 (1) = 31.964, p < .001). Those who lost track of time were significantly less likely to not have experienced GTP (13.4% vs. 27.2%) while those who did not lost track of time were

Table 3
Chi-square of the use of AR and sound and the different GTP types.

GTP types	AR					Sound				
	Off	On	X^2	*d.f.*	p value	Off	On	X^2	*d.f.*	p value
Visualized/seen PoGo images with closed eyes	45.1	37.8	0.990	1	.320	39.7	46.3	0.643	1	.423
Yes	54.9	62.2				60.3	53.7			
No										
Seen PoGo images with my eyes open			0.261	1	.610			0.540	1	.462
Yes	26.2	23.0				23.8	29.3			
No	73.8	77.0				76.2	70.7			
Seen distorted real-life environments and/or objects			0.497	1	.481			0.377	1	.539
Yes	9.0	12.2				7.9	11.0			
No	91.0	87.8				92.1	89.0			
Misperceived a real-life object as something from PoGo			4.434*	1	.035			3.240	1	.072
Yes	18.0	31.1				17.5	30.5			
No	82.0	68.9				82.5	69.5			
Bodily sensations of movement as if I was in PoGo			0.006	1	.936			5.243*	1	.022
Yes	13.1	13.5				7.9	22.0			
No	86.9	86.5				92.1	78.0			
Tactile (touch) sensation associated with a PoGo			0.230	1	.631			3.757	1	.053
Yes	27.9	31.1				20.6	35.4			
No	72.1	68.9				79.4	64.6			
Perceived body differently after playing PoGo			4.516*	1	.034			4.891*	1	.027
Yes	4.1	12.2				1.6	11.0			
No	95.9	87.8				98.4	89.0			
I have felt as though the mind has disconnected from the body			1.421	1	.233			3.058	1	.080
Yes	8.2	13.5				4.8	13.4			
No	91.8	86.5				95.2	86.6			
Re-experienced music from PoGo			3.889*	1	.049			10.035**	1	.002
Yes	34.4	48.6				28.6	54.9			
No	65.6	51.4				71.4	45.1			
Re-experienced sounds from PoGo			3.844*	1	.050			6.666*	1	.010
Yes	27.0	40.5				22.2	42.7			
No	73.0	59.5				77.8	57.3			
Re-experienced voices from PoGo			3.206	1	.073			3.335	1	.068
Yes	16.4	27.0				14.3	26.8			
No	83.6	73.0				85.7	73.2			
Misinterpreted sound IRL for something from PoGo			4.510*	1	.034			13.307***	1	.000
Yes	24.8	39.2				15.9	44.4			
No	75.2	60.8				84.1	55.6			
Wanted or felt the urge to do something in real life triggered by a PoGo-related cue			0.002**	1	.969			0.488	1	.485
Yes	51.6	51.4				54.0	59.8			
No	48.4	48.6				46.0	40.2			
I have experienced still being in the mindset of PoGo after playing			0.164	1	.686			2.695	1	.101
Yes	27.0	29.7				20.6	32.9			
No	73.0	70.3				79.4	67.1			
Thinking about using something from PoGo when not playing			2.712	1	.100			5.326*	1	.021
Yes	25.4	36.5				19.0	36.6			
No	74.6	63.5				81.0	63.4			
Mixed up PoGo events with actual real-life events			1.125	1	.289			7.167**	1	.007
Yes	25.4	32.4				17.5	37.8			
No	74.6	67.6				82.5	62.2			
Sang, shouted or said something from PoGo unintentionally			2.787	1	.095			1.503	1	.220
Yes	59.8	71.6				57.1	67.1			
No	40.2	28.4				42.9	32.9			
Movement of arms or fingers involuntarily in response to a PoGo related cue			2.536	1	.111			4.577*	1	.032
Yes	5.7	12.2				3.2	13.4			
No	94.3	87.8				96.8	86.6			
Acted out behaviour or performed an activity influenced by PoGo			0.091	1	.762					
Yes	17.2	18.9				14.3	22.0	1.382	1	.240

(*continued on next page*)

Table 3 (*continued*)

GTP types	AR					Sound				
	Off	On	X^2	*d.f.*	p value	Off	On	X^2	*d.f.*	p value
No	82.8	81.1				85.7	78.0			
Acted differently in real-life situations because of something experienced in PoGo unintentionally			3.516	1	.061			1.918	1	.166
Yes	5.7	13.5				6.3	13.4			
No	94.3	86.5				93.7	86.6			

* p < .05.
** p < .01.
*** p < .001.

Table 4
Correlations between immersion and GTP in the full sample and the sub-samples.

GTP subscales	Full sample (n = 1240)	EnS (n = 1035)	SpS (n = 205)	Z-test	p-value
GTP overall	0.490**	0.490**	0.599*	2.9	.004
APO	0.449**	0.444**	0.567**	3.2	.001
AVP	0.421**	0.415**	0.489**	2	.050
AAP	0.278**	0.271**	0.422**	4.3	.000
ABP	0.368**	0.354**	0.485**	3.6	.000
AMP	0.416**	0.419**	0.441**	0.6	.559
BAA	0.344**	0.336**	0.508**	4.7	.000

APO = Altered perceptions overall, AVP = Altered visual sensorial perceptions, AAP = Altered auditory sensorial perceptions, ABP = Altered body perceptions, AMP = Automatic mental processes, BAA = Behaviours and actions.
** Correlation is significant at the 0.01 level (2-tailed).
* Correlation is significant at the 0.05 level (2-tailed).

significantly less likely to have experienced GTP (72.8% vs.86.6%).

Looking for Pokémon outside the screen by mistake while playing was significantly associated with GTP (χ^2 (1) = 22.011, p < .001). Those who looked outside the screen for Pokémon while playing were significantly less likely to not have experienced GTP (4.9% vs. 19.1%).

Having the sensation that Pokémon was present in the real world was significantly associated with GTP (χ^2 (4) = 31.539, p < .001). Those who had the sensation that Pokémon were present in the real world were more likely to have experienced GTP (97.5% vs 80.2%) while those who had not had the sensation Pokémon were present were more likely to not have experienced GTP (19.8% vs. 2.5%).

Further analysis was conducted to examine correlations between a composite immersion variable (created by summarising all immersion related variables) (See information about the reliability and factor analysis in the Measures section).

Immersion was positively moderately correlated with GTP in the full sample. In the EnS the correlation between immersion and GTP was moderate, while in the SpS the correlation was strong. In the full sample, immersion was moderately correlated with all sub-scales of GTP except auditory, which was weakly correlated. In the EnS all the correlations between immersion and the sub-scales were moderate except auditory, which was weakly correlated. In the SpS most correlations between immersion and the sub-scales were moderate; only altered perceptions overall, and behaviours and actions were strongly correlated (see Table 4).

Further analyses were conducted to determine if there were significant differences between the correlations of GTP and immersion in the sub-samples, by comparing the correlations (r values) in each sub-sample after transforming into Z-scores. The difference between these correlations was statistically significant in most of the sub-scales; only automatic mental processes did not show statistically significant differences (see Table 4).

Table 5
Correlations between immersion and the use of AR and sound in SpS.

	AR (n = 196)	Sound (n = 145)
Forgetting what is happening around oneself while playing	0.151*	0.244**
Losing track of time	0.110	0.180*
Looking for Pokémon outside the screen	0.206**	0.258**
Having the sensation that Pokémon is physically present	0.118	0.249**

** Correlation is significant at the 0.01 level (2-tailed).
* Correlation is significant at the 0.05 level (2-tailed).

3.8. Video game features and immersion

The AR feature was only weakly correlated with forgetting what is happening around oneself while playing, and looking for a Pokémon outside the screen. Hearing sounds from PoGo was also weakly correlated with all the variables of immersion (see Table 5 for the full results of the correlations).

4. Discussion

This study aimed to investigate the prevalence of GTP in a sample of English- and Spanish-speaking PoGo gamers, examine the effects of immersion, and the impact of playing with the AR function enabled and playing with sound on the different manifestations of GTP.

Most participants played video games other than PoGo, and most have played Pokémon games before PoGo, which resembles the typical profile of the PoGo gamers according to the video game industry (Walker, 2016). Moreover, the typical frequent mobile phone gamer tends to be female, 39-years-old, who spends an average of 15 h per month playing on the mobile phone (Hwong, 2017). In the current study, half of the participants were female gamers, and their average age was 31-years-old. Most studies about GTP (including this) have not found any significant differences between genders in the prevalence of GTP (Dindar and Ortiz de Gortari, 2017; Ortiz de Gortari and Griffiths, 2016), although one study conducted with another location-based augmented reality game (*Ingress*) found that females experienced a larger incidence of GTP (Sifonis, 2016).

4.1. Prevalence of GTP

Those who had experienced GTP with PoGo were significantly more likely also to have experienced GTP with other video games. More than four of five participants experienced GTP when playing PoGo at some point, but the prevalence of GTP was lower in comparison to previous studies. A relatively low prevalence was reported for all GTP sub-scales (sensorial perceptions, mental processes and behaviours) in both sub-samples, although the prevalence in the SpS was significantly higher than in the EnS (SpS 89.6% vs. EnS 80.9%). The majority showed low severity levels of GTP in the full sample and in both sub-samples. Ortiz de Gortari and Griffiths (2016) reported a prevalence of GTP of 96.6%. Similarly, a study with a Turkish sample reported 99% of prevalence of GTP (Dindar and Ortiz de Gortari, 2017). Lastly, in a study on the "predecessor" to PoGo, *Ingress* (Niantic, 2013) an incidence of 96.6% of GTP was found (Sifonis, 2016).

Previous studies have found that playing frequently (e.g., every day) and in long sessions (e.g., 3 h or longer) are relevant for GTP, and severe GTP (Ortiz de Gortari and Griffiths, 2015; Ortiz de Gortari et al., 2016). Therefore these variables were also investigated in this study, to try to understand the differences between the sub-samples. The results showed that in general, the SpS tend to play more intensively than the EnS. More gamers in the SpS tend to play 36 h or more per week, and fewer in the SpS played sessions shorter than 30 min. Moreover, there were a larger number of younger gamers (18–22-years-old) in the SpS than in the EnS. Previous studies have found that younger adults (Ortiz de Gortari and Griffiths, 2016) and minors (15 +) (Dindar and Ortiz de Gortari, 2017) are more likely to experience GTP.

Many of the predominant types of GTP found in relation to playing PoGo, are the same as those found to be more predominant in previous studies (e.g., visualised/saw images with closed eyes, heard music from the game, sang, shouted or said something from the game unintentionally) (Dindar and Ortiz de Gortari, 2017; Ortiz de Gortari and Griffiths, 2016). The two most prevalent forms or manifestations of GTP in both sub-samples and the full sample were "wanted or felt the urge to do something after seeing some game-related cue" and "sang, shouted or said something related to the game unintentionally". However, significant differences were observed between the EnS and SpS. The most common modality of GTP in the full sample and in the EnS was automatic mental processes, while in the SpS it was behaviours and actions. The least common modality in the full sample and in both sub-samples was altered body perceptions. These findings are similar to previous studies (Dindar and Ortiz de Gortari, 2017; Ortiz de Gortari and Griffiths, 2016). "Still being in the mindset of the game" was the only GTP type that was significantly more likely to be reported by the EnS. These findings are also similar to a previous study that compared GTP experiences between an English-speaking sample and a Spanish-speaking sample (Ortiz de Gortari, 2015a).

Regarding the level of severity of GTP, most in the full sample and in both sub-samples showed low levels of GTP (a few forms of manifestation of GTP and low frequency of experiences), similar to previous studies (Ortiz de Gortari et al., 2016).

4.2. Comparing the prevalence of the GTP types

4.2.1. Visual experiences

Visualizing or seeing images with closed eyes was the most common visual experience, and experiencing perceptual distortions of objects and environments was the least common in the full sample and in the sub-samples. The low prevalence of perceptual distortions might be explained by the lack of visual effects (SFX) (e.g., slow motion, changes of colours, textures and patterns) in PoGo. Another explanation for the low prevalence of perceptual distortions and the rather low prevalence of seeing images with open/closed eyes can be the relatively short exposure to visual elements when playing PoGo since gamers are constantly changing their view from the device to the real world. The length of the playing sessions, including for those who experienced GTP, tends to be 90 min or shorter. Only seeing images with open eyes was significantly more likely to be experienced by those in the SpS. Interestingly, a previous study (that did not focus on any particular video game) found that the Spanish-speaking sample had a larger

prevalence of seeing images with open eyes in comparison with an English-speaking sample (Ortiz de Gortari, 2015a). Studies on hallucinations in schizophrenia have found cross-cultural differences (Bauer et al., 2011).

4.2.2. Auditory experiences

Re-experiencing music from video games, has been found to be the most predominant auditory experience, while the least prevalent has been hearing voices (Dindar and Ortiz de Gortari, 2017; Ortiz de Gortari and Griffiths, 2016). This was confirmed in the current study. Regarding the sub-samples, the SpS showed higher prevalence in all the auditory experiences. In the location-based augmented reality game *Ingress*, Sifonis (2016) reported that auditory-related GTP experiences were the least reported by those who had played the game. Similarly, in the present study, auditory-related experiences were less common than in previous studies (Dindar and Ortiz de Gortari, 2017; Ortiz de Gortari and Griffiths, 2016). This may be explained because PoGo tends to be played without sound and the aural cues in PoGo are less rich and not as salient as in other video games. Many gamers stated that they played the game with the sound turned off in the EnS while slightly more than one third in the SpS never played with the sound turned on. As expected, those who played PoGo with the sound on in the SpS were significantly more likely to report replays of music or sounds from the game. The sound feature was significantly associated with most of the GTP modalities and many forms of manifestation. Engaging in musical activities has been found to be related to the likelihood of music-related imagery (Liikkanen, 2012). Interestingly, conversations with gamers have revealed that even though they did not play with the sound turned on any longer; they had the illusion of hearing the auditory cues from the game while playing it, to the degree that is annoying.

4.2.3. Body and other altered sensorial perceptions

The most prevalent body-related GTP among PoGo gamers was feeling tactile sensations or tactile hallucinations (e.g., feeling vibrations or feeling the fingers pressing the screen), in contrast from previous studies, where the most prevalent body-related experience was illusions of bodily movement as being in the game – related to the vestibular system (similar to the "Mal de Débarquement" that occurs after exposure to passive motions mostly when travelling by sea (Ombergen et al., 2016). The importance of the interaction with tangible surfaces appears evident, and this finding was expected because playing PoGo requires touching the device's screen and feeling vibrations such as alerts for when Pokémon are nearby. Studies have reported tactile hallucinations and sensations associated with vibration alerts from mobile phones (Drouin et al., 2012; Lin et al., 2013). Gamers have also reported feeling vibrations and touch sensations of gamepad buttons when not playing (Ortiz de Gortari and Griffiths, 2014a, 2016). The spectrum of these types of experiences may broaden with the future use of haptic devices (e.g., gaming vests such as KOR-FX or Control VR) (Ortiz de Gortari, 2015b). Comparable to a previous study (Ortiz de Gortari, 2015a), the SpS showed a significantly higher prevalence of sensations of bodily movements and tactile sensations in GTP-related experiences.

4.2.4. Automatic mental processes

Wanted or felt the urge to do something as in the game, triggered by some stimuli in the physical world, was the most prevalent GTP item in the automatic mental processes sub-scale in the full sample. Automatic mental processes was not significantly associated with any particular sub-sample, similar to a previous study (Ortiz de Gortari, 2015a), and it was the most prevalent in the EnS and the second most prevalent in the SpS. The high prevalence of this experience shows the importance of associations between video game elements and physical world game-related stimuli for some GTP to occur (Ortiz de Gortari and Griffiths, 2016). However, in location-based augmented reality games, the previous exposure to physical objects and locations may be even more relevant than in other video games because the gameplay takes place in the physical world and re-encountering physical places/objects (e.g., landmarks) can easily act as a trigger for spontaneous phenomena. Moreover, more than one in four of the PoGo gamers reported still being in the mindset of the game after stopping playing; those in the EnS were significantly more likely to have experienced it. Location-based games may facilitate this type of GTP, since once gamers stopped playing they continued interacting in the physical world which was used as the base of the gameplay. This may be experienced as to keep applying the rules of the game (e.g., kept paying attention to coloured objects in the same way as paying attention to colourful Pokémon that appear, kept looking for PokeStops or gyms, etc.).

4.2.5. Behaviours and actions

Lastly, the most common GTP regarding actions and behaviours was have sung, shouted, or said something with the game contents (e.g., caught yourself referring to real life animals with similar Pokémon names like saying "Pidgey" instead of pigeons, humming the song of Pokémon Go involuntarily); this was also the most prevalent behaviour-related GTP found in previous studies (Dindar and Ortiz de Gortari, 2017; Ortiz de Gortari and Griffiths, 2016). Once again, it was more common in the SpS than in the EnS (Ortiz de Gortari, 2015a). The only behaviour-related experience not different between the sub-samples was: acted differently in real life situations because of encountering something related to PoGo.

4.3. Use of video game features

The most interesting question concerning the use of the AR function in PoGo, was to know if seeing digital creatures overlaid on the real world using the AR function was related to seeing images from the game after playing (Ortiz de Gortari et al., 2011; Ortiz de Gortari and Griffiths, 2014a). GTP overall or GTP in any of the sub-scales (visual, auditory experiences) was not significantly associated with the AR function. However, GTP items in various sensory modalities (e.g., felt body differently after playing, re-experienced music or sounds, misinterpreted a sound) were associated with the AR function. But, the only item associated with AR among the visual experiences was visual misperceptions, but not visualisations or seeing images (i.e., seeing images with closed or

open eyes) as was expected. On the one hand, this suggests that the overlaying of digital images, even when the images are seen via the device's screen rather than in a more natural way (i.e., looking at them directly using AR glasses), facilitates confusions or misperceptions of the objects later on. Discriminating errors tend to occur when stimuli are interpreted based on previous experiences, especially when the stimuli have characteristics in common (Summerfield et al., 2006). On the other hand, the absence of associations between re-experiencing seeing images with open/closed eyes, suggest the relevance of other factors not involve with the use of AR. These can be for instances i) the time of exposure to video game images, ii) view fixation on the screen, iii) the type of images (e.g., brightness, colour) and iv) individual factors.

Furthermore, as expected, auditory experiences such as hearing replays of music, sound and misperceptions of sound were more likely to be reported by those who tend to play the game with the sound turned on. It is interesting to notice that even though the sound features in PoGo are not salient, the background music and the few sound effects are enough so that almost one out of five in the SpS experienced replays of music or sounds. Re-experiencing voices was not related to the sound feature which is explained by the lack of voices in PoGo. These results confirm the importance of the video game features for the type and content of the GTP experiences, which has been argued in previous studies on GTP (Ortiz de Gortari, 2016a; Ortiz de Gortari and Griffiths, 2014b).

Feeling the body differently after playing was also significantly associated with the AR function and playing with the sound turned on. Lastly, it was also found that more of those who played with sound have experienced wanting to use something from the game (e.g., want to use a Poké Ball to catch a fly, have committed errors by mixing up video game events with actual events that have happened in the physical world, and have confused sounds in the physical world with those from PoGo). Music and sound have been found to be effective to induce mood and physiological responses (Gerra et al., 1998; Tafalla, 2007) and change of behaviour (Kallinen, 2002; Kuribayashi and Nittono, 2015).

4.4. Immersion

The relation between GTP and experiencing immersion while playing was found to be associated with GTP (Ortiz de Gortari and Griffiths, 2015). In the current study, experiencing immersion while playing PoGo was positively correlated with overall GTP and all the sub-scales in the full sample; however, the strength of the correlations varied along the sub-scales and between the sub-samples. A closer examination of each of the immersion variables: i) losing track of time, ii) forgetting what is happening around you, iii) looking for Pokémon outside the screen, and iv) feeling the physical presence of a Pokémon, showed in the full sample that more of those who reported forgetting what was happening around them when playing and losing track of time (Jennett et al., 2008) tend to have experienced GTP. Additionally, those who found themselves looking for Pokémon outside the screen were more likely to have experienced GTP. For instance, a participant commented: "While playing the game I will often look up at the landscape as if I would be able to see a Pokémon!". Looking for Pokémon outside the screen denotes immersion in the game and appears to resemble typical slips of action (Norman, 1981). Slips of action can also commonly occur when switching between devices, such as wanting to scroll on a screen that is not a touchscreen, after having touched and scrolled on the screen of a mobile phone or tablet. This experience resembles when gamers found themselves looking for video game elements in real life contexts when not playing (Ortiz de Gortari et al., 2011; Ortiz de Gortari and Griffiths, 2014b). In this study, this variable was considered as a factor of immersion rather than GTP because it happens while playing. Future studies should consider the differences between computer/console games and other games (e.g., location-based AR games) when assessing GTP, and take into account at what point GTP manifests (i.e., while playing or after playing). Moreover, those who reported having the sensation that Pokémon were physically present as a measure of immersion were more likely to have experienced GTP. This may be explained by individual characteristics related to the proneness to GTP.

Regarding the relation between immersion and PoGO features (i.e., sound and AR function), it was found that sound was more relevant for the immersion variables investigated. This finding shows the importance of auditory cues even in location-based augmented reality games. Playing PoGo with sound was weakly positively correlated with forgetting what is happening around oneself while playing, losing track of time, looking for a Pokémon outside the screen and having the sensation that a Pokémon is physically present.

Using the AR function was only correlated with forgetting what is happening while playing and as expected it was correlated with looking for a Pokémon outside the screen, but surprisingly it was not correlated with having the sensation that a Pokémon was physically present.

Future studies should investigate the relationship between using the AR and sound features, forgetting what is happening around and losing track of time, and incidents associated with PoGo that had been reported in the media and in various studies (Kari, 2016).

5. Limitations

This study is not without limitations. First, the participants were recruited from online groups dedicated to Pokémon Go on Facebook, and the results may only be representative of those inclined to join affiliations online. Also, as in the majority of studies with self-reports, this study might suffer from sampling bias (e.g., social desirability bias, recall bias, etc.). Research has shown that proficient gamers or those who are more involved in the game are more motivated to participate in online surveys (Khazaal et al., 2014). Second, the scale instrument to assess GTP, the GTPS (Ortiz de Gortari and Griffiths, 2016) was originally developed in the context of computer and console video games, though the items can easily be adapted to the context of particular games. However, some items show limitations when it comes to investigating AR games because GTP has been conceptualized as post-play experiences since the experiences tend to occur after playing (Ortiz de Gortari and Griffiths, 2016), while in location-based augmented reality games GTP experiences appear to occur while playing. Third, playing the game using the AR function and with sound activated was

only investigated in one sub-sample, the SpS. This implies that only those who play with the AR function enabled should be considered playing an AR game; otherwise, the game should only be considered a location-based game. In this study, it is unknown how many of the EnS played with the AR function or with sound. Future studies into AR games should include this question if they are examining AR games that allow playing without the AR mode. The relation between GTP, AR, and playing with sound should be investigated in a larger sample. Fourth, the comparison between the samples is only based on the language, which does not allow establishing specific comparisons regarding cross-cultural backgrounds. Future studies should compare gamers with different cultural backgrounds rather than only establishing comparisons based on language.

6. Conclusions and further research

Findings in this study suggest that GTP is prevalent in location-based mobile games with optional augmented reality features.

The findings also suggest that being immersed in the game is important for gamers to experience GTP. Moreover, the various types of GTP that were more likely to be reported by the PoGo gamers (e.g., tactile sensations rather than sensations of self-motion) than when playing video games in other platforms, shows the importance of the platform where the game is played (i.e., smartphone with touchscreen), the video game features embedded in the game and the way the game is played (e.g., playing the game with or without sound for re-experiencing music from the game).

Regarding the use of AR and sound, it was interesting to find that both AR and sound were significantly associated with feeling the body differently even though PoGo does not appear to induce embodiment to the same degree as most other video games are capable of (Hofer et al., 2017).

Furthermore, it is also important to notice that using the AR function was only significantly associated with visual misperceptions but not with seeing game-related images with open or closed eyes or with visualising game-related content. Future studies should try to explain the different physiological and cognitive mechanisms involved in seeing images and experiencing misperceptions associated with AR. Also, it is important to keep in mind that even though most PoGo gamers tend to not use the AR function, playing PoGo require the gamers to search for digital creatures (non-tangible or non-existent) in physical contexts, facilitating mix-ups or confusions between the virtual and the physical world.

Interestingly, some gamers reported feeling the sense of presence of digital characters, particularly those who had experienced GTP, which shows the enormous potential of augmented reality/mixed-reality technologies to change our perception of reality, enhancing it or distorting it.

Another interesting finding (even though the prevalence of GTP was lower in PoGo) was that the types of GTP that were less or more common in the sub-samples were also the same types as in the English- and Spanish-speaking samples in a previous study that investigated GTP without focusing on any particular game (Ortiz de Gortari, 2015a). In this study, the differences between the sub-samples appear to be explained by video game habits and demographical factors (e.g., session length, age), but cross-cultural differences should be investigated in the future with gamers from different cultural backgrounds.

Future studies should also investigate the prevalence of GTP that occur while playing in addition to those that occur after playing. This study suggests that GTP that is experienced while playing (reported by 16.3% in a previous study) (Ortiz de Gortari and Griffiths, 2016) may be predominant when playing AR games and/or location-based games compared to other video games. The gameplay in these types of games takes place in the physical world which may facilitate automatic associations between in-game elements and physical elements, misperceptions, source monitoring errors, absent-mindedness, slips of actions (e.g., looking for video game elements beyond the game screen while playing), and cognitive perseverations, phenomena that can be potentially used for positive means (e.g., therapeutic use of AR games or for learning). Cognitive failures are part of everyday life but denote deficits in attention and memory, and can lead to accidents and minor injuries, particularly when they occur in public contexts (Simpson et al., 2005). Therefore, it is important to be vigilant for the challenges AR technologies posit, to be able to harvest the benefits for personal use, education and health that these technologies offer; technologies that instead of immersing us in a virtual world, blend digital elements with the physical world.

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