

# Exploratory preferences explain the cultural success of imaginary worlds in modern societies

Edgar Dubourg<sup>1 a</sup>  
Valentin Thouzeau<sup>1</sup>  
Charles de Dampierre<sup>1</sup>  
Nicolas Baumard<sup>1</sup>

<sup>1</sup> Institut Jean Nicod (Paris), ENS, EHESS, CNRS, PSL

<sup>a</sup> Corresponding author: edgar.dubourg@gmail.com

**Abstract:** Imaginary worlds are one of the hallmarks of modern culture. They are present in many of the most successful fictions, be it in novels (e.g., *Harry Potter*), films (e.g., *Star Wars*), video games (e.g., *The Legend of Zelda*), graphic novels (e.g., *One piece*) and TV series (e.g., *Game of Thrones*). This phenomenon is global (e.g., the worldwide success of *Lord of the Ring*, the emergence of *xuanhuan* and *xanxia* genres in China), and massive: people spend an increasing amount of time, energy and resources involved in fictions with imaginary worlds. Why so much attention devoted to non-existent worlds? In this paper, we propose that imaginary worlds co-opt exploratory preferences, a set of cognitive preferences that have evolved in humans and non-human animals to motivate individuals to explore new sources of reward. Imaginary worlds are fictional superstimuli that tap into the human's interest for unfamiliar and potentially rewarding environments. This theory predicts that 1) fictions with imaginary worlds should be more appealing for individuals higher in Openness to experience (because this personality trait is associated with exploratory preferences), 2) such fictions should be more attractive for younger people (because young people reap more rewards from exploratory behaviors) and 3) such fictions should be more successful in more economically developed societies (because affluent ecologies lower the costs of exploration). We successively test these predictions with two large cultural datasets, namely IMDb (N=85,855 films) and Wikidata (N=96,711 novels), as well the Movie Personality Dataset, which aggregates averaged personality traits and demographic data from the Facebook myPersonality Database (N=3.5 million), the films they like on Facebook and metadata for films from the Internet Movie Database (IMDb). We provide evidence that the appeal for imaginary worlds relies on our exploratory psychology.

**Keywords:** cognitive attraction, cultural evolution, cultural distribution, exploration, fiction, imaginary worlds, openness to experience

## 1. Introduction

The consumption of fictions has become a central behavior in modern societies, with individuals spending a considerable and growing amount of time watching films and TV series, reading novels and playing video games. For instance, people spend each day as much as 1 to 3 hours watching

video on demand (Statista, 2021) and video gamers all over the world spend an average of 6 hours and 20 minutes playing games each week (The State of Online Gaming, 2020). With a large-scale survey, Our World in Data estimated how people spend their daily time, across 23 countries: the average share of TV consumption is 2 hours, that is approximately 8% of the day, and this percentage of time spent watching TV outgrows the time spent doing sport, shopping, seeing friends, attending events or of personal care in all countries except India. Why such an attraction to fiction?

The most successful fictions today have something crucial in common: they almost always contain an imaginary world, that is, a fictional world different from the real world, one that the audience could not have explored in real life (Besson, 2015; Ryan, 2014; Saler, 2012; Wolf, 2013): *Star Wars* is the most lucrative media franchise in history; *Lord of the Ring: The Return of the King* holds the record of the most Oscars won by a single movie and is the 5<sup>th</sup> film in the “all-time top-rated movies” list from IMDb; *Harry Potter* is the best-selling book series of all time; *Game of Thrones* holds the all-time audience record for a TV series; *One Piece* is the best-selling manga series of all time; *The Avengers: Endgame* is the highest-grossing movie of all time; and *Zelda* is the best-selling video game series in the world. They all develop an imaginary spatial environment.

Scholars have argued that the evolution and success of cultural items in general, and of fictions in particular, rely on evolved features of the mind (Acerbi, 2020; Boyd, 2018; Boyer, 1998; Buss, 2015; Carroll, 1995; Claidière & Sperber, 2007; Gottschall, 2012; Scott-Phillips et al., 2018; Sperber, 1996; Sperber & Hirschfeld, 2004). Masks tap into the well-known facial recognition mechanism (Sperber & Hirschfeld, 2004) while rituals tap into the human evolved precaution systems (Boyer & Liénard, 2006). In the same way, fiction makers target and exaggerate preexisting preferences in humans (Fisher & Salmon, 2012; Saad, 2012, 2013; Vanderbeke & Cooke, 2019). For instance, our appeal for fictions has been said to rely on evolved preferences for social information targeted by fiction makers, e.g., about romantic relationship (Alberti, 2013; Cox & Fisher, 2009; Salmon & Symons, 2004; Vanderbeke, 2019), cooperation and cheating (Singh, 2019), social status (Nettle, 2005a, 2005b) and political rivalries (Jobling, 2001).

In light with this framework, we propose that fictions with imaginary worlds are highly attractive because their imaginary worlds co-opt an evolved hardwired preference for spatial exploration (Dubourg & Baumard, 2021). Exploratory preferences are best described as a set of cognitive mechanisms which process cues of novel and unfamiliar environments as input and, depending on ecological and psychological factors, delivers or not an adaptive approach behavior as the output, so as to maximize future rewards (Cohen et al., 2007; Dubey & Griffiths, 2020; FitzGibbon et al., 2020; Gozli, 2018; Hills et al., 2010; Oudeyer et al., 2016; Schulz & Gershman, 2019; Stojic et al., 2020). Because imaginary worlds are defined as unknown and unfamiliar fictional settings, they can be seen as new environments that consumers discover and want to explore. As Tolkien put it himself, “part of the attraction of *The Lord of the Rings*”, and other fictions with imaginary worlds, relies on the intrinsic feeling of reward we experience when “viewing far off an unvisited island or the towers of a distant city” (letter to Colonel Worskett, 20 September 1963). This statement is very close to the one of Shigeru Miyamoto, the creator of *Zelda*, who reported that he “wanted to create a game world that conveyed the same feeling you get when you are exploring a new city for the first time” (1989).

In behavioral ecology and evolutionary psychology, it has been shown that exploratory preferences vary according to individual traits and ecological cues (Schaller & Murray, 2008). More precisely, humans deal with an exploitation-exploration trade-off and they tend to choose an exploratory strategy when the evolutionary benefits of exploration are higher than the costs. Two key factors weigh in this trade-off. Sensitivity to risk is the first one: individuals show much more propensity to exploration in an environment with steady and predictable level of resources, because the risk of the investment is lowered (one is safe with the resource already acquired if the exploration doesn't pay off). This explanation is backed up by empirical research in animals (English et al., 2016; Humphreys et al., 2015; Rojas-Ferrer et al., 2020; Spivey et al., 2008) and humans (Frankenhuis et al., 2016; Glowacki & Molleman, 2017; Jacquet et al., 2019; Nettle, 2019). The second factor is time horizon: the benefits of exploration increase if the findings it leads to can be exploited for a longer period of time in the future (one is better off exploiting if their expected life expectancy is short). This rationale is also supported by empirical research (Eliassen et al., 2007; Maspons et al., 2019) and evolutionary modelling (Boon-Falleur et al., 2020; Mell et al., 2019).

In light of this literature, the hypothesis that imaginary worlds co-opt exploratory preferences leads to three predictions about cultural consummatory behaviors. First, individuals high in the Big Five psychological trait openness to experience should be more attracted to imaginary worlds, because this trait is correlated with novelty-seeking behavior (Costa et al., 2014; DeYoung, 2011; Krebs et al., 2009), exploratory preferences (George & Zhou, 2001; Gocłowska et al., 2019, 2019; Li et al., 2014; McCrae, 1993) and spatial cognitive capacities (Cashdan & Gaulin, 2016; Davis & Cashdan, 2019). Therefore, if imaginary worlds co-opt our exploratory preferences, part of the variation of preferences for fictions with imaginary worlds should be explained with the scores of Openness to experience of the consumers, independently of cultural differences.

Second, younger individuals should be more attracted to imaginary worlds. This is the case because (1) the time-horizon variable makes exploration more adaptive for younger individuals, whose expected life expectancy is higher (Gopnik, 2020) and (2) major costs associated with exploration are outweighed by parental investments (Kaplan et al., 2009), making exploration much less risky. This is supported by empirical evidence that younger individuals are more explorative and more skilled at exploring (Gopnik et al., 2015, 2017; Lucas et al., 2014).

Third, the indicator of cultural success for imaginary worlds in specific countries should be correlated with indicators of economic development. This is the case because the level of exploratory preferences is adaptively higher in ecologies with high and steady level of resources. In line with this idea, previous works have shown that economic development can lead to changes in individual preferences (e.g., trust (De Courson & Nettle, 2021; Martins & Baumard, 2020; Safra et al., 2020), exploration (Baumard, 2019) and self-discipline (Baumard et al., 2015; Fitouchi et al., 2021)). We thus predict that a higher level of economic development should be associated with higher share of imaginary worlds in fictions.

## 2. Study 1: The share of fictions with imaginary worlds increases with time

In this first study, we tested whether the success of fictions with imaginary worlds is really a modern phenomenon. It could be the case that the success of *Harry Potter* and *The Lords of the Rings* is not representative of the popularity of fictions with imaginary worlds in general, and that they are the exception rather than the rule. Besides, the popularity of imaginary worlds is not specific to the early 21<sup>st</sup> century. The works of Jules Verne and Orson Wells were already very popular in the late 19<sup>th</sup> century, and the rise of pulp fictions in the early 20<sup>th</sup> century (e.g., *Amazing Stories*, *Astounding Stories*) demonstrates the appeal of imaginary worlds in the early 20<sup>th</sup> century. To date, no quantitative study has tested the idea that imaginary worlds are culturally more important in more modern societies.

### 2.1. Data

For films, we used the IMDb dataset (N=85,855). For each film, we selected the title, the year of release and the genres. For novels, we built a Novel Dataset by extracting metadata on Wikidata of all instances of “written work” and “literary work” (N=96,711). For each literary work in the dataset, we extracted the title, the year of publication, the country and the genres, and removed the genres associated with non-fiction (e.g., “essay”, “biography”, “non-fiction”; see Supplementary Information). If the year of publication was not available, we took the floruit date of the author, and when not available either, we extracted the birth year of the author and added 35 (inferring that the floruit period of an author is around 35 years old). If the country was not available, we took the country of birth of the author, and, as a last resort, the language of the book.

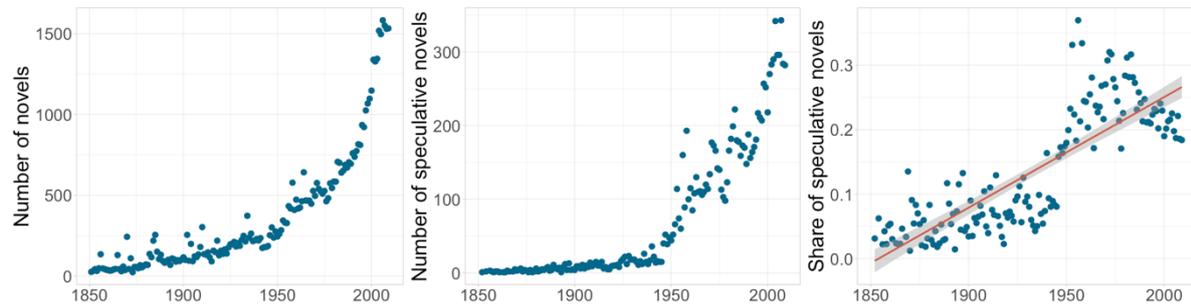
### 2.2. Method

In the IMDb dataset, we identified 2 out of the 21 genres that fitted the category of speculative fiction (see Supplementary Information), which is a good proxy for fictions with imaginary worlds (Dubourg & Baumard, 2021). In the Wikidata dataset, literary works are associated with many genres. We removed genres appearing fewer than 10 times in the whole dataset. We identified 25 genres out of the remaining 239 that fitted the category of speculative fictions (see Supplementary Information). For each dataset, we plotted the evolution of the number of works of fiction per year, the evolution of the number of speculative fictions per year, and the evolution of the share of speculative fictions per year. We also estimated the association between time and the share of speculative fictions with Linear Models, with the year of release as the explanatory variable and the share of speculative fictions as the outcome variable.

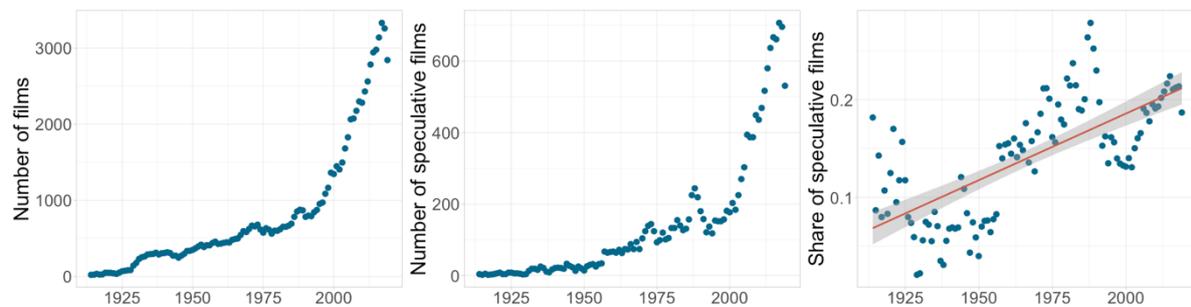
### 2.3. Results and discussion

The share of speculative fictions increases across recent history, despite the fact that the numbers of both novels and films increased exponentially. Linear Models estimate highly significant and positive increases in the share of speculative novel ( $\beta=1.715e-03$ ,  $p<.001$ , adjusted  $R^2=0.67$ ) and films ( $\beta= 0.0013642$ ,  $p<.001$ , adjusted  $R^2=0.49$ , see Figures 1 and 2). In line with qualitative observations about the success of imaginary worlds (Besson, 2015; Ryan, 2014; Saler, 2012; Wolf,

2013), this study demonstrates that fictions with imaginary worlds are more and more popular as time goes by.



**Figure 1.** The evolution of the number of speculative novels, as a proxy for the evolution of fictions with imaginary worlds, with data of literary works from 1850 to 2000, extracted from Wikidata ( $N = 96,711$ ). A. The evolution of the number of novels published per year. B. The evolution of the number of speculative novels published per year. C. The evolution of the share of speculative novels published per year.



**Figure 2.** The evolution of the number of speculative films, as a proxy for the evolution of fictions with imaginary worlds, with data of films from 1913 to 2020, extracted from IMDb ( $N = 85,855$ ). A. The evolution of the number of films released per year. B. The evolution of the number of speculative films released per year. C. The evolution of the share of speculative films released per year.

### 3. Study 2: Individuals higher in openness to experience are more attracted to imaginary worlds

#### 3.1 Data

We used the Movie Personality Dataset (MPD) which aggregates averaged personality and demographic traits from the Facebook myPersonality Database ( $N=3.5$  million) and metadata on films from the Internet Movie Database (IMDb). More precisely, MPD associates to each film ( $N=846$ ) the average scores of the Big Five of all the people who liked them on Facebook (Nave et al., 2020). Nave et al. (2020) built an important dataset that makes it possible to map the associations between movie characteristics and the personality characteristics common to people who like such films. We also used a bigger dataset from IMDb ( $N=9,872$ ) which almost completely overlaps with MPD (802 out of 846 films in MPD are also in IMDb). For this dataset, we extracted metadata from IMDb, namely, the box-office and the user-generated keywords, which describe “any notable

object, concept, style or action that takes place during a title” (IMDb), and which are cross-validated by multiple users.

### 3.2. Methods

Following the view that plot keywords are more predictive of psychological dimensions of consumers than traditional fictional genres (Nave et al., 2020), we decided not to use the broad classification of genres. We applied a random forest algorithm (Breiman, 2001) in order to perform a classification. The objective was to estimate, for each film, whether or not it is set in an imaginary world. A random forest consists of a set of decision trees. The construction of an individual tree begins by randomly selecting a subset  $\sqrt{n}$  of plot keywords, with  $n$  the total number of keyword plots retained (see below). The tree is then built step by step. It selects the first keyword that best separates the movies dataset into two subsets and determines whether the presence or absence of this plot keyword is more often associated with an imaginary world or not. For each branch, it then selects the plot keyword that further subdivides optimally the movies in that branch into two subsets and repeats this process until no plot keyword classifies the movies more precisely than the branch already does. The tree resulting from this algorithm thus decides, for each film evaluated, whether it is set in an imaginary world or not.

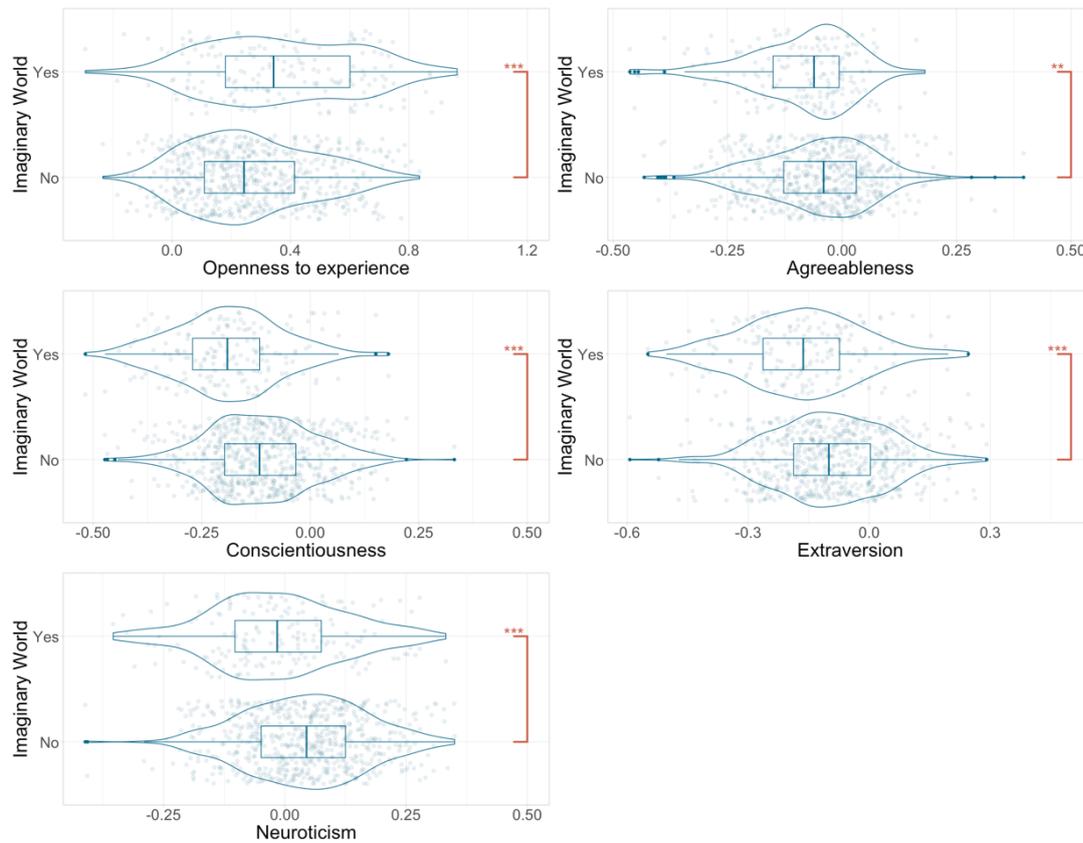
The random sampling of different subsets of  $\sqrt{n}$  plot keywords allows to build 500 decision trees. The consensus of the 500 votes from the trees is used to determine the final category of the films. We verified that 500 trees were sufficient for the error rate to converge. To determine which plot keywords are most informative, we ordered them according to their correlation with the imaginary world category. We then tested which threshold  $n$  of plot keywords retained in the building of the random forest minimized the classification error. We used these  $n$  most informative plot keywords to train the final random forest. To limit the bias of subsampling (movies in an imaginary world being in the minority), we selected an identical number of movies that were and were not set in an imaginary world to train the algorithm.

To further test that this algorithm is efficient in discriminating films with imaginary worlds, we first made some case-to-case verification by looking at Wikipedia summaries of 50 films randomly selected. We found no mismatch. Then, we computed a Linear Probability Model with the binary variable Imaginary World as the independent variable, and the genres of the films as the explanatory variables. Films with imaginary worlds are generally found in the science fiction and fantasy genres, and to a lesser extent in the adventure genre (Dubourg & Baumard, 2021). As predicted, the science fiction and fantasy genres significantly increased the probability that the film set an imaginary world ( $\beta > 0$ ,  $p < 0.001$ ). The thriller, action and adventure genres were also associated to films with imaginary worlds ( $\beta > 0$ ,  $p < 0.05$ ). It is worth noting that multiple genres are associated to each film, hence the correlation between these genres and the presence of imaginary worlds (e.g., *Tomb Raider*, from 2018 is categorized in the Action, Adventure and Fantasy genres). Interestingly, the romance genre was negatively correlated with our variable ( $\beta < 0$ ,  $p < 0.05$ ). The other genres showed no significant association with imaginary worlds. Overall, these results are consistent with our expectations and suggest that our algorithm is robust.

For each film, we added our new binary variable which takes the values of 1 (if the film is set in an imaginary world according to the algorithm) and 0 (if the film is not set in an imaginary world) in the two datasets we use (i.e., the MPD with psychological and demographic traits, and the restricted IMDb with the box-office). To test the correlations between the appeal for films with imaginary worlds and the average score of Openness to experience of the consumers, we used Linear Probability Models, with scores of the personality traits as explanatory variables, and the binary variable of the presence or absence of an imaginary world as the outcome variable.

### 3.3. Results and discussion

We found a positive correlation between the liking of films with imaginary worlds and the Openness to experience score ( $\beta=0.35$ ,  $p<.001$ ,  $CI[0.22, 0.47]$ ). According to this model, an increase of one unit in Openness to experience is associated with an increase of the probability of the films preferred setting an imaginary world of 0.35% (**Figure 3**). The other traits of the Big Five were all negatively correlated with the liking of films with imaginary worlds (Agreeableness:  $\beta=-0.40$ ,  $p=0.0011$ ,  $CI[-0.64, -0.16]$ ; Conscientiousness:  $\beta=-0.84$ ,  $p<.001$ ,  $CI[-1.06, -0.62]$ ; Extraversion,  $\beta=-0.59$ ,  $p<.001$ ,  $CI[-0.78, -0.39]$ ; Neuroticism,  $\beta=-0.57$ ,  $p<.001$ ,  $CI[-0.79, -0.35]$ ). These results are in line with previous works (using smaller samples, and less accurate categories) demonstrating an association between Openness to experience and specific genre such as science fiction and fantasy (Annalyn et al., 2020; Cantador et al., 2013; Ersonality, 2010; Kraaykamp & Eijck, 2005).



**Figure 3.** Violin plots and box plots of the average personality scores of people who liked films with imaginary worlds and films with no imaginary world. \*\*\*  $p<0.001$ , \*\*  $p<0.01$ , \*  $p<0.05$ .

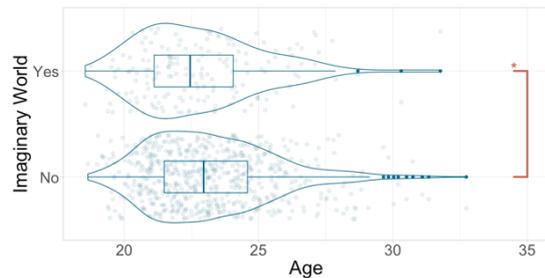
## 4. Study 3: Younger individuals are more attracted to imaginary worlds

### 4.1. Data and method

We used the same datasets and method as in the previous study. A Linear Probability Model estimated the effect of the average age of consumers (the explanatory variable) on the liking of films with imaginary worlds on Facebook (the outcome variable).

### 4.1. Results and discussion

We found a negative correlation between the liking of films with imaginary worlds and the age of the users ( $\beta = -0.013$ ,  $p = 0.035$ ,  $CI[-0.02, -0.0009]$ ). According to this model, a one-year increase in age is associated with a decrease of the probability of the films preferred setting an imaginary world of 0.02% (**Figure 4**). The weakness of the coefficient can be explained by the restricted range of the ages represented in the dataset (between 18,5 and 32,7). A much higher estimated coefficient and a more significative correlation might emerge with a wider and more varied sample (Facebook users are much younger than the general population, especially in the period 2007-2012). Nonetheless, this result is in line with our prediction.



**Figure 4.** Violin plot and box plot of the age of people who have liked films with imaginary worlds and films with no imaginary world. \*\*\*  $p < 0.001$ , \*\*  $p < 0.01$ , \*  $p < 0.05$ .

## 5. Study 4: Films with imaginary worlds are more successful in more affluent societies

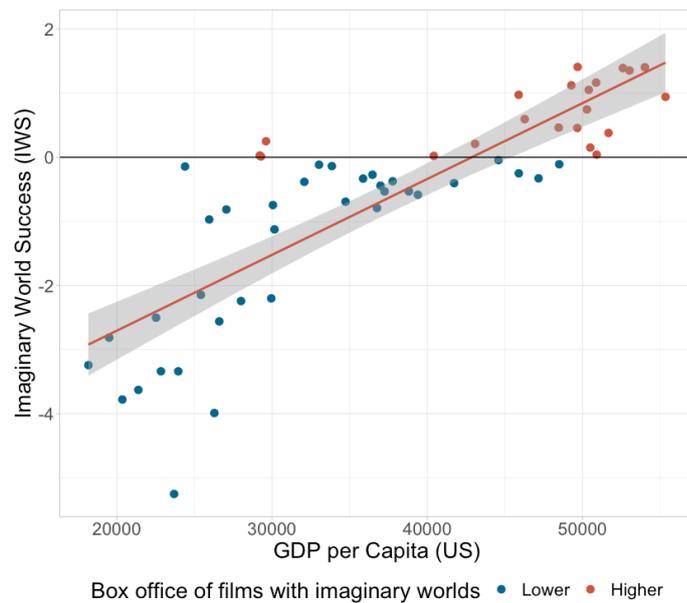
### 5.1. Data and method

In the case of films, we have a better measure of success than the sole share of speculative fiction, namely the box office numbers. We thus used the IMDb dataset and extracted the box offices of each film in the United States. We chose the United States because this is the country for which there is the most data on IMDb and because, in most countries, the production from the US actually accounts for the majority of the movies. We computed, for each year, the difference of the means of box-offices for films with imaginary worlds and films with no imaginary world. We called this new variable the IWS indicator (for Imaginary World Success, i.e., an indicator of the relative

success of films with imaginary worlds). When, for a given year, IWS is negative, it means that the mean box-office of films with imaginary worlds is lower than the mean box-office of films with no imaginary world. Conversely, if IWS is positive, it means that the mean box-office of films with imaginary worlds is higher than the mean box-office of films with no imaginary world that year. That is, the value and the sign of this variable tells us about the success of films with imaginary worlds relative to other films, across time. We finally used a Linear Model with the GDP per capita as the explanatory variable (Manning, 2017) and the IWS indicator as the outcome variable.

## 5.2. Results

With a Linear Model, we found a positive correlation between GDP per capita and the IWS ( $\beta=8.022e-05$ ,  $p<.001$ , adjusted  $R^2= 0.37$ ; **Figure 5**). The model estimated that the cultural shift from which films with imaginary worlds became more successful than the others happens when the GDP exceeds 42919.47\$ (where the regression line of the model crosses the horizontal line  $y=0$ ).



**Figure 5.** The success of films with imaginary worlds (IWS) as a function of the GDP per capita in the United States (logarithmically scaled), with a horizontal line at  $y=0$  (above which the mean box office of films with imaginary worlds becomes bigger than the mean box office of films with no imaginary world, at a given year) and a regression line for the Linear Model.

## 6. Study 5: Novels with imaginary worlds are more successful in more affluent societies

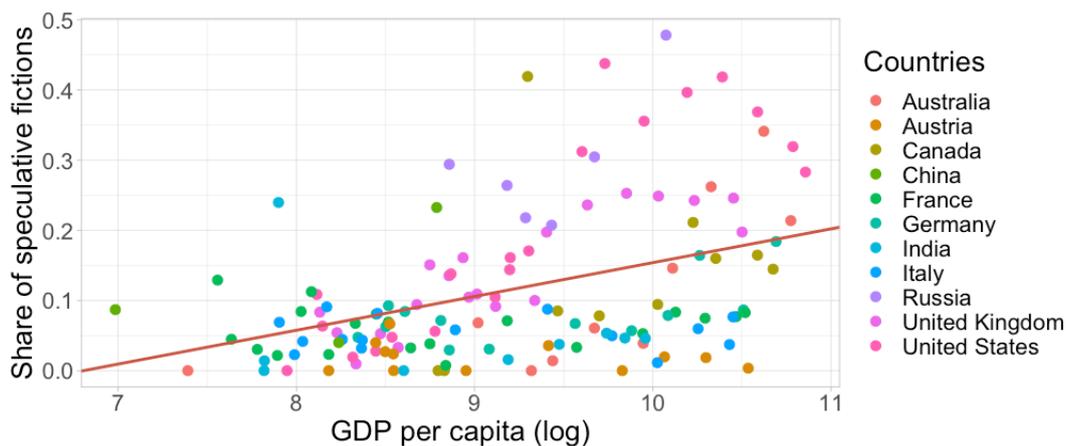
### 6.1. Data and method

For novels, sales are not available. On the other hand, the temporal depth of the study can be much greater, going back to the middle of the 19<sup>th</sup> century. We used the Novel Dataset from study 1

(section 2). We filtered for countries with more than 1,000 literary works referenced in Wikidata (i.e., Australia, Austria, Canada, China, France, Germany, India, Italy, Russia, the United Kingdom and the United States;  $N=44,608$ ). We then computed, for each decade and country, the number of novels, the number of speculative novels, and, after having filtered for decades with more than 20 novels, we computed the share of speculative novels. For each decade-country pairs, we added the mean GDP per capita (Manning, 2017). We fitted a Linear Mixed-Effect Model to the data, with the GDP as the explanatory variable, the share of speculative fictions as the outcome variable, and countries as random factor.

## 6.2. Results and discussion

We found trends indicating that, in most countries, when GDP per capita increases, the share of speculative fictions rises too (**Figure 6**). Overall, in these 11 countries, the GDP of a decade significantly predicts the share of speculative fictions in literary works that same decade. We found a positive and significant association between GDP and the share of speculative novels ( $\beta=0.048218$ ,  $p<.001$ ).



**Figure 6.** The share of speculative novels (as a proxy for the success of novels with imaginary worlds) as a function of the log of GDP per capita in 11 countries, with a regression line of the Linear Mixed Effect Model.

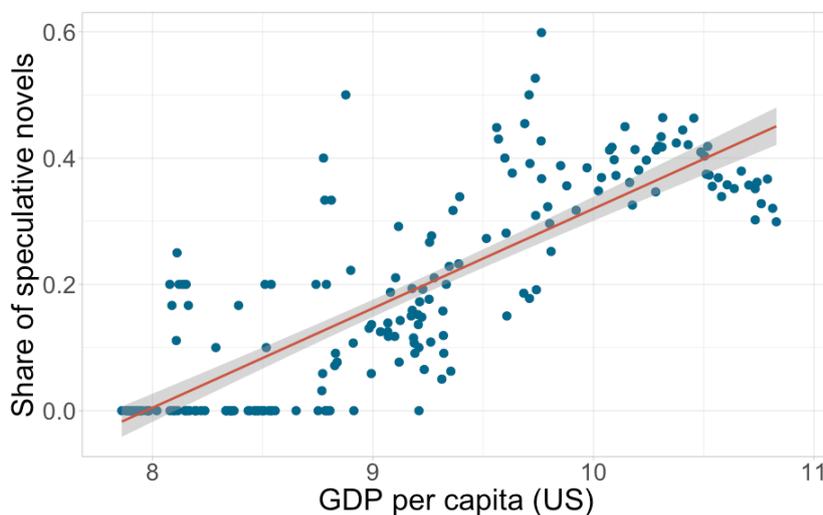
It is worth noting that these results fit qualitative observation about the cultural evolution of imaginary worlds. Modern imaginary worlds emerged first in the United Kingdom (Wolf, 2013), which was at the time the leading country in term of GDP per capita (Manning, 2017), and then mostly developed in the Euro-American sphere. By contrast, for most of the 19<sup>th</sup> and 20<sup>th</sup> centuries, their popularity was rather limited in less economically developed countries. For instance, while Jules Verne was first translated in Chinese in the early 20<sup>th</sup> and inspired Chinese writers to write science-fiction and fantasy stories during the late Qing dynasty and early Republican era, fictions based on imaginary worlds remained marginal in Chinese literature during the 20th century (Jiang, 2013; Lu, 2000).

In East Asia, imaginary worlds started to become mainstream first in Japan in the 50's (Takayuki, 2000) which had started its industrialization in the late 19<sup>th</sup> century, then in Hong-Kong and Taiwan (Rehling, 2012), which had started to develop economically in the 1970. During the same time,

imaginary worlds were much less popular in mainland China (Jiang, 2013; Song, 2013) and they really became mainstream in mainland China in the turn of the new millennium, that is, 20 years after the take-off of the Chinese economy (Ni, 2020; Song, 2013; Xu, 2017).

### 6.3. Replication restricted to the US sample

We replicated this study for the United-States only, for two methodological reasons. First, it is the country for which we had more data ( $N=27,432$ , the second country being the United Kingdom with less than half as much works). This allowed to run the same analysis at the yearly level, rather than the decade level. The second reason stems from the fact that we aim at understanding consumers' preferences. However, we only have data on literary production in each country. Therefore, our data cannot account for the consumption of translated works, which is a high percentage in most countries, except for the US. For instance, French readers have arguably consumed a lot of speculative novels since the genre appeared. Yet, after WWII, most of this consumption involves American rather than French fictions. In line with this observation, the French National Book Center indicates that 19% of literary production comes from abroad (Piault, 2017), and arguably this number is probably much higher for genres like science-fiction and fantasy (around 45%; Vincent, 2018). In comparison, the United States are known to mostly consume national literature (only 3% of literary production comes from translated foreign literature) and speculative genres such as science fiction is known to be "home-made" (Roberts, 2016). This makes the United States a good test-case to study fiction consumption through data about literary production. With a Linear Model, we find positive correlations between GDP per capita and the share of speculative novels in the United-States ( $\beta=0.15747$ ,  $p<.001$ , adjusted  $R^2=0.67$ ; **Figure 7**).

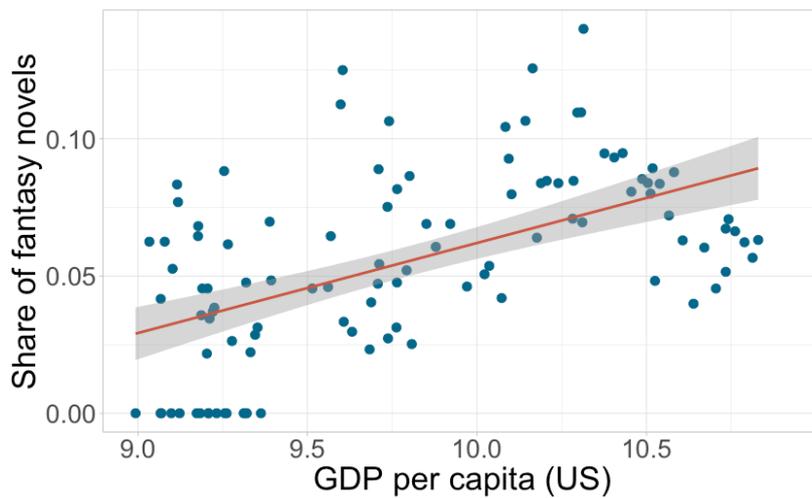


**Figure 7.** The share of American speculative novels (as a proxy for the success of novels with imaginary worlds) as a function of the GDP per capita in the United States (logarithmically scaled) with the regression line of the Linear Model.

### 6.4. Replication with fantasy only

One way to explain the association between economic development and the share of speculative fiction is that, since the Industrial Revolution, economic development is associated with

technological development. Thus, speculative fiction, and science-fiction in particular, could become more popular simply because technology is becoming more popular in more developed countries, and not because individual's preferences are becoming more exploratory (Rees & Morus, 2019; Roberts, 2016; Song, 2013). To rule out this 'technophilia' alternative, we conducted the same analysis with fantasy and fantastic genres (where technology does not play a role), but not to the science fiction genre. With a Linear Model, we still found a positive correlation between GDP per capita and the share of fantasy novels ( $\beta=0.032803$ ,  $p<.001$ , adjusted  $R^2=0.29$ ; **Figure 8**).



**Figure 8.** The share of American fantasy novels (as a proxy for the success of novels with imaginary worlds) as a function of the GDP per capita in the United States (logarithmically scaled), with the regression line of the Linear Model.

## 7. Discussion

As predicted by the exploration hypothesis (Dubourg & Baumard, 2021), fictions with imaginary worlds are (1) more preferred by people higher in openness to experience, (2) more preferred by younger people and (3) more preferred in affluent societies. Overall, these results support our hypothesis that imaginary worlds in fictions tap into our exploratory preferences. Such preferences are adaptively more expressed where people can afford to be more opened to new experiences, e.g., in more affluent ecologies, and when the costs of exploration are lower, and the benefits are more long-lasting, e.g., when time horizon is higher (Baumard, 2019). Overall, our results are in line with the idea that cultural items are all the more successful that they tap into specialized evolved cognitive mechanisms (Boyer, 1998; Buss, 2015; Claidière & Sperber, 2007; Sperber, 1996; Sperber & Hirschfeld, 2004),

This study contributes to a better understanding of fiction at several levels. First, while most studies of fictions have focused on plots and protagonists, our study confirms that fictional settings are important, and more and more so. Second, while several works have used an evolutionary framework to explore the *universal* appeal of certain kinds of fictions (e.g. romances (Alberti, 2013; Cox & Fisher, 2009; Salmon & Symons, 2004; Vanderbeke, 2019), tragedies (Nettle, 2005a, 2005b)), our

study is the first to use an evolutionary framework to explain the *variable* appeal of a certain kinds of fiction (Baumard, 2017; Hyafil & Baumard, 2020).

Our study is of interest for the understanding of cultural evolution in general. If we are right, the increasing appeal of imaginary worlds in contemporary societies suggest that individuals are becoming more exploratory and more open to experience (this is in line with international surveys showing a shift in individual preferences during the late 20<sup>th</sup> century and the early 21<sup>st</sup> century. (Inglehart, 2020)). This massive change in people's preferences could have important consequences in the political domain for instance, since Openness to experience is associated with higher level of tolerance and lower level of authoritarianism.

Our results also suggest that, as developing countries are catching up with developed countries, their fictional culture will progressively converge with the one of the developed countries (Kuipers & de Kloet, 2009). East Asia is a case in point here, with the increasing success of imaginary worlds in Japan, Taiwan, Korea and China (see discussion of study 5). For instance, Liu Cixiu, the author of the world acclaimed science fiction novel *The Three Body Problem* notes that “At the time of the *Three-Body's* publication, China's science fiction market was anxious and depressed. The long marginalization of science fiction as a genre led to a small and insular readership.” (Liu, 2014). By contrast, science-fiction and fantasy are immensely popular today in China, and Chinese imaginary world are becoming to be exported to developed countries (Bould, 2009; Junker, 2019)

More generally, our study suggests that the consumption of fictions and culture could be an important tool in the study of psychological preferences (Martins & Baumard, 2020). While fictions only inform indirectly about individual preferences, they are much more ecological and finely tuned to individual preferences than questionnaires, and they inform us about the preferences of millions, if not billions of people. They also allow for repeated measures as each film, each novel, each video game can be seen as an observation. It worth noting that fictions can be used to understand the present and the future, but also the past (Baumard et al., 2021). For instance, the cultural popularity of imaginary world in pre-industrial societies could inform us about the level of Openness to experience in societies for which behavioral data are scarce.

Finally, more work is needed to assess the exploration hypothesis. Our results should be replicated with other datasets. We were limited by the current data available, which is far from being exhaustive for most countries and for other fiction types. For instance, it would be interesting to test whether the quantitative analysis of the success of fictions with imaginary worlds and its association with affluence indicators replicate in non-Western developed countries (e.g., Japan, Korea) and in non-Western developing countries (e.g., India, Nigeria). It would also be interesting to test this association with other fictional media, such as video games or TV series. Also, Studies 4 and 5 do not directly test the causal effect of an increase in exploratory preferences on the success of imaginary worlds. It would be interesting to find a way to measure the evolution of psychological preference in history, and to test whether it is associated with an increasing appeal for imaginary worlds.

**Acknowledgment:** Sacha Altay, Hugo Mercier.

**Funding statement:** This work was supported by the FrontCog funding (ANR-17-EURE-0017).

**Conflicts of Interest:** None.

## ORCID

Edgar Dubourg: 0000-0002-2162-6526

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