

Pushing the boundaries of reality: Science fiction, creativity, and the moral imagination

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## Abstract

Past research suggests that reading science fiction (sci-fi) correlates not only with a propensity to think the impossible could become possible, but also with a tendency to say that morally taboo actions could be permissible in some circumstances (Black, Capps, & Barnes, 2017). Here, in a pre-registered experimental study, we tested the immediate effects of exposure to sci-fi television shows on moral imagination and creativity. Although there were no main effects of viewing sci-fi (compared to viewing realistic television and a control), we found an interaction between condition and narrative engagement: in the sci-fi group only, participants who reported feeling less transported into the story tended to subsequently generate fewer scenarios in which normally taboo acts would be morally permissible (compared with highly transported individuals in the sci-fi group as well as both the control and realistic TV show groups). The same pattern of results held for creativity: there was a significant interaction between condition and narrative engagement, such that there was an effect of transportation only for those who watched sci-fi, with participants who were more transported into the sci-fi narrative generating more unique uses for a common object than those who experienced low transportation into sci-fi. This pattern of results is discussed with respect to the cognitive demands of engaging with science fiction.

Key words: MORALITY, IMAGINATION, SCIENCE FICTION, CREATIVITY,  
COUNTERFACTUAL GENERATION

**Pushing the boundaries of reality: Science fiction, creativity, and the moral imagination**

Science fiction is best known for describing worlds beyond—sometimes far beyond—the reach of contemporary technology; amongst sci-fi readers, the genre is perceived as making them more likely to be open to and enhancing their understanding of real-world science (Menadue & Jacups, 2018). Interestingly, the genre often pushes moral and ethical boundaries as well (Stockwell, 2014). In *Star Wars*, for example, we see clones as well as space ships, and Ursula Le Guin's 1969 novel *Left Hand of Darkness* challenges the meaning of sexuality when the protagonist describes his experiences on a completely androgynous alien planet. Accepting the possibility of futuristic technology that is not yet available and accepting the potential permissibility of actions seen as taboo in the real world both demand stretching the imagination to consider counterfactual scenarios. Past studies have revealed a positive correlation between such possibility and permissibility judgments (Black, Capps, & Barnes, 2017; Shtulman & Tong, 2013), and both are positively related to familiarity with science fiction authors (Black et al., 2017). In the current study, we investigated the causal effect of viewing sci-fi television on moral imagination (operationalized as the ability to generate circumstances under which a taboo action would be permissible) and creativity (operationalized as alternate uses for commonplace objects) in a pre-registered experiment ([osf.io/c2k36](https://osf.io/c2k36)), testing an interaction model in which transportation into the narrative was expected to moderate the effect of TV genre on the outcome variables.

**Theoretical Framework**

We designed our study with two broad theories in mind. First, we explored a theory of sci-fi as imaginative practice; to the extent that sci-fi stretches the bounds of reality, perhaps it actually improves the audience's ability to imagine; however, due to the distance one must

imaginatively “travel” to engage with fictional worlds far removed from our own, some people may find engaging with sci-fi particularly challenging. As such, we also based our hypotheses on Transportation Theory (Green & Brock, 2000, 2002), which argues that the extent to which consumers engage with a narrative determines its impact on them, when it comes to both persuasive influence (Appel & Richter, 2010; Bal & Veltkamp, 2013; Green, 2004) and enjoyment (Green, Brock, & Kaufman, 2004; Hall & Bracken, 2011). These theories and our corresponding hypotheses are outlined in more detail below.

**Science Fiction as Imaginative Practice.** Prior research has shown that exposure to sci-fi in print (Mara & Appel, 2015) and film (Appel, Krause, Gleich, & Mara, 2016) makes futuristic technology feel less eerie and more likable, relevant, and potentially useful. Moreover, there is correlational evidence that exposure to sci-fi relates to greater openness to experience (Fong, Mullin, & Mar, 2013; Stern, Robbins, Black, & Barnes, 2018), which has been consistently associated with greater creativity (McCrae, 1987). Further, there is some empirical evidence that exposure to sci-fi enhances creativity directly: middle school students who had been randomly assigned to watch a sci-fi film (vs. control) subsequently designed and produced robotic cross-country vehicles that received higher creativity product assessment scores (Lin, 2014; see also Lin, Tsai, Chien, & Chang, 2013). Although to the best of our knowledge there have been no experiments to test the effect of sci-fi exposure on creativity in adults, “science fiction prototyping” (SFP; Johnson, 2011) is a method used to encourage creative thinking for product and service innovation by inventing sci-fi storyworlds within which to better identify, prepare for, and create future trends and needs. SFP can be used for consumer product innovation (Zheng & Callaghan, 2018), security (“threatcasting;” e.g., Vanatta & Johnson,

2018), human-computer interaction technology education (Jordan & Silva, 2019), and creative thinking more generally.

Given the imaginative content and technological focus of science fiction, it is unsurprising that sci-fi readers, entrepreneurs, and scientists (*Nature* editorial, 2018) believe exposure to the genre can encourage creativity. Following sci-fi plots requires counterfactual thought (e.g., accepting that space travel is possible as a premise), or, if we suppose that sci-fi content may someday become reality, imagining could suppose what Byrne and Egan (2004) call “prefactual conditionals.” Such counterfactual/conditional reasoning relies on creativity (Byrne, 2007; Roese, 1994) as well as cognitive effort (Byrne, 2016). In line with the idea that there may be a relationship between exposure to sci-fi and individual differences in counterfactual thinking, Black and colleagues (2017) found a positive correlation between lifetime exposure to sci-fi and both the belief that the impossible could become possible and the belief that immoral or taboo actions could sometimes be permissible.

The question remains whether such correlational effects, possibly the result of a lifetime of practice constructing mental models of story worlds that run counter to reality, would be seen after a one-off exposure to sci-fi media. Busselle and Bilandzic (2008) identify the process through which readers build mental models as follows: readers (in any medium) approach stories with schemas based on either the real world or prior narrative experience and update those schemas into story-specific mental models as information is presented in the text; models must be created for the world of the story, the plot, and the characters. Notably, although this can be effortful, when a reader becomes truly absorbed in a story, the process might more closely resemble a flow-state. Busselle and Bilandzic suggest that the ease with which this state is

achieved may depend both on the realism of the story and on the reader's access to well-developed genre schema, which can be used to short-cut the process.

Because sci-fi, by definition, departs from reality, the effort required to build a model of the story world—while simultaneously building and updating models for the characters and the plot—may be particularly taxing for individuals with less cumulative exposure to the sci-fi genre. As with any exertion and in line with ego depletion models (Baumeister, Bratslavsky, Muraven, & Tice, 2000), it could be that employing the imagination to construct the mental models needed to understand sci-fi worlds would result in mental fatigue in the immediate aftermath for individuals who fail to achieve a flow-state (high transportation) while watching. Experimental research shows that cognitive effort affects not only analytical reasoning (Schmeichel, Vohs, & Baumeister, 2003) but also moral judgment (Timmons & Byrne, 2018): participants who had been put under cognitive fatigue were more likely (compared with controls and norms from literature) to judge acts impermissible, presumably because they could make mental models that allowed them to consider the possible outcomes less easily. This outcome was particularly interesting for the present research: if prior cognitive effort affects moral judgment, then viewing sci-fi might deplete the imagination for circumstances when a taboo act would be permissible despite the positive association between permissibility and long-term sci-fi exposure (Black et al., 2017), particularly for individuals who are unable to become absorbed in the narrative.

**Transportation Theory.** Imaginative engagement with narrative has often been conceptualized as *transportation* (Gerrig, 1991), or the extent to which readers or viewers become emotionally and cognitively involved in the story (Green, 2004; Green & Brock, 2000, 2002). People who are truly transported into a narrative are fully immersed in and absorbed by

the story, losing track of the real world. Those who feel more transported into narratives enjoy them more (Green, Brock, & Kaufman, 2004; Hall & Bracken, 2011); they also, perhaps because transportation involves losing oneself in a story at the expense of awareness of the real world (Green & Brock, 2000), find a story more realistic when they have felt transported into its world (Green, 2004; Hall & Bracken, 2011). Various investigations have highlighted the importance of transportation as a mechanism contributing to effects of fiction exposure: transportation into narratives has been shown to lead to greater prosocial behavior (Johnson, Cushman, Borden, & McCune, 2013), more effective persuasion (Appel & Richter, 2010), greater empathy (Bal & Veltkamp, 2013), and greater likelihood of endorsing story-consistent beliefs (Dal Cin, Zanna, & Fong, 2004; Green, 2004).

Although individuals may differ on trait transportability—that is, how easy it is to lose themselves in stories, generally (e.g., Dal Cin et al, 2014; Mazzocco, 2010)—state transportation also depends on characteristics of the story, as well as the individual relationship between the story and the reader (e.g., Green, 2004). Importantly for the current study, familiarity with a fictional genre may make engagement easier and, if the fictional world is complex as is typical of sci-fi, more appealing (Bilandzic & Busselle, 2008). Transportation has been compared to *flow*, or the immersion in a challenging activity to the exclusion of all else (Busselle & Bilandzic, 2008; Csikszentmihalyi, 1991; Green, 2004); flow is not effortless, but rather requires a balance between ability and challenge. The construction of mental models of the fictional world is work that requires effort of media consumers (Busselle and Bilandzic, 2008). They will be most likely to experience flow and therefore maximally enjoy the narrative when understanding the story is just challenging enough to engage the right amount of effort: this in turn will depend on individual preferences (Sherry, 2004). As such, any effects of viewing sci-fi that depend on

transportation could be subject to participants' familiarity with the genre and their reaction to the specific stimuli used.

### **The current research**

The primary purpose of this study was to test the theory that sci-fi exposure affects creativity and to build on past research showing correlational evidence of a positive association between sci-fi exposure and moral permissibility judgments (Black et al., 2017). In light of the existing evidence of this association, we were particularly interested in the effects of sci-fi exposure on moral imagination, operationalized as the quantity of scenarios that would make normally immoral actions permissible participants could imagine (details below). Because the imagination for such counterfactual situations could depend on general creativity, we also tested the effect of viewing sci-fi on a separate outcome variable, the Alternate Uses Test (Guilford, 1967). We expected sci-fi exposure to affect both outcome variables, but because people may find imagining instances where immoral acts would be allowable difficult if not impossible (Black & Barnes, 2017; Phillips & Cushman, 2017), it was possible that there would be no effect on moral imagination, or that only for moral imagination would there be a difference between viewing sci-fi and other television. In order to better identify the unique effect of sci-fi, if any, we compared the performance of three groups on two creative tasks (moral imagination and general creativity): two groups viewed either sci-fi or realistic TV, and a control group completed the outcome variables before viewing sci-fi TV.

Participants were randomly assigned to view the pilot episode of either sci-fi or realistic TV series or to a control condition, where participants completed the outcome measures prior to viewing a sci-fi show. If watching sci-fi affects creativity, there would be a difference in creativity across groups (sci-fi, realistic, control; Hypotheses 1a [moral imagination] & 2a



[general creativity], non-directional; see Table 1). These hypotheses were non-directional because we had identified two possibilities that seemed plausible: sci-fi could increase creativity via imaginative practice or by priming participants to think beyond normal moral and physical constraints or sci-fi could decrease creativity due to the effort required to build mental models of the story world, leaving participants mentally tired and less inclined to exert cognitive effort. More importantly, any main effect could be qualified by an interaction between condition and transportation into the narrative.

Previous studies suggest that the effects of fictional content can depend on narrative engagement (transportation as a mediator: Green & Brock, 2002 [Study 4]; Johnson, Cushman, Borden, & McCune, 2013; transportation as a moderator: Appel & Richter, 2010; Mazzocco, 2010; Richter, Appel, & Calio, 2014). If sci-fi has a unique effect on creativity either through priming or depleting the imagination, then we would not expect to see an association between transportation and the outcome variables in the realistic or control conditions. As such, we predicted an interaction between condition and transportation into the stimuli, such that for the sci-fi group only, reported transportation into the narrative would be positively correlated with creativity (H1b [moral imagination] & H2b [general creativity]). In other words, within the sci-fi group only, we expected participants at high levels of transportation to demonstrate greater imagination and creativity than those at low levels of transportation.

Finally, we tested whether the ability to imaginatively engage with fiction can be depleted by requiring participants to use their imaginations prior to viewing. Thus, we compared reported imaginative engagement (operationalized as transportation into the narrative) for the sci-fi experimental group (who viewed sci-fi prior to completing other imaginative tasks) and the control group, who watched the same sci-fi shows after completing those tasks. To the extent

that narrative engagement requires work (e.g., to construct mental models of the fictional world), then having already employed the imagination in creative tasks could lessen the degree to which participants are subsequently transported. In this study, if imagination for fiction—operationalized as the ability to become transported into the story—can be depleted by prior imaginative work, then participants in the control group (who completed the Creativity tasks *first*) would report being significantly less transported into the sci-fi narrative (Hypothesis 3; see pre-registration [osf.io/c2k36](https://osf.io/c2k36) for details).

## Method

### Participants and procedure

A power analysis estimating a medium effect size indicated the need for  $N = 196$ , but data collection was determined by the needs of the subject pool (see pre-registration) such that 268 college undergraduates completed the study in exchange for course credit. Of these, 27 had prior experience with the TV show (followed the series/had seen pilot episode or 10+ other episodes) and were discarded. Fifteen more were discarded: three reported low English language skills, three had excessive guessing on the author recognition test (see below for description; foils or fake names are used to screen for bad data), and nine were multivariate outliers on two or more criteria (predicting outcome from moral judgment pre-test; three in control group, two in Realistic TV group, four in Science-Fiction group). The final sample was  $N = 226$  (81.9% female, 92.5% under 21 years). Males and females were evenly distributed across the three conditions,  $\chi^2(df = 2) = 0.07, p = .967$ .

All participants completed the pre-test Moral Judgment Task (MJT; described below) as part of a departmental online prescreening survey at least two weeks before the experiment. Participant were randomly assigned at lab session level (1-3 people) to one of three conditions:

control, sci-fi, or realistic TV. Within each condition, participants were randomly assigned to one of two shows; the control group completed the outcome measures first, and then watched one of the sci-fi shows. All participants completed questions about their experience with the corresponding TV series followed by the Transportation Scale immediately after viewing the TV show. The experimental groups then completed the outcome measures (moral imagination and creativity). Finally, all participants completed demographic questions, a brief questionnaire about their preferences for difference genres, and an author checklist.

### **Stimuli**

Participants watched approximately 40 minutes of the pilot episode of one of four TV series, *Firefly* (the long pilot required pausing the show at 42 minutes, which coincides with a good stopping point), *Continuum*, *Castle*, or *Jane the Virgin* (all watched in their entirety). The two sci-fi shows, *Firefly* and *Continuum*, were chosen because they featured two of the most prominent motifs in science fiction: spaceships (*Firefly*) and time travel (*Continuum*), but are not widely viewed among the undergraduate demographic studied here. The sci-fi shows varied in tone (*Firefly* is often comedic; *Continuum* is a drama), setting (*Continuum* is set on earth, largely in the present day; *Firefly* is set in the future and takes place in space and on other planets), subgenre (*Continuum* is a police drama; *Firefly* codes largely as a Western set in space), and protagonist gender. Thus, although both shows are clearly science fiction and center on popular sci-fi motifs, they differ on many other traits, thereby representing a broader spectrum of the genre.

After the selection of the sci-fi shows, two realistic shows were chosen to match the sci-fi stimuli in key ways, such that each realistic show shared commonalities with both *Firefly* and *Continuum*. *Castle* is a police drama (like *Continuum*) that is similar in tone to *Firefly* and stars

the same leading actor (Nathan Fillion). In contrast, *Jane the Virgin* focuses on a female protagonist who finds herself in a highly unlikely situation (as in *Continuum*) and shares with *Firefly* prominent familial relationships, a focus on economic/political disparities, and the juxtaposition of comedy and drama. Brief descriptions of each show, as well as the plot of the pilot episode viewed by the participants, appear below.

*Firefly* is a space Western focusing on the lives of a group of renegade space travelers. The pilot, which aired in 2002, introduces the viewer to the crew of the eponymous spaceship and their past, as well as to the passengers they pick up. Over the course of the episode, the crew attempts to evade the authorities of the all-powerful Alliance government to fence stolen goods. Most of the episode takes place on or around (in spacesuits) the spaceship, but the first few minutes are a flashback of a war that could be present day.

*Continuum* is a science fiction drama that focuses on a group of terrorists and a female police officer who travel in time from the year 2077 to 2012. The pilot, which aired in 2012, shows the protagonist, Kiera Cameron, infiltrating the Vancouver police department in order to track down the terrorists before they can start a war and also documents Kiera's interactions with a teenage boy who will one day become an important figure in their world.

*Castle* is a police procedural about an author of crime fiction who begins to consult for the police department on real-world murders. The pilot episode, which first aired in 2009, shows Richard Castle (Nathan Fillion) being drawn into a case in which a serial killer is mimicking the murders in Castle's books.

*Jane the Virgin* is a "romantic dramedy" about a woman named Jane who is waiting for marriage to have sex, but becomes pregnant when she is mistakenly artificially inseminated with the sperm of a man whose family owns the hotel where she works. The pilot episode, which

aired in 2014, features an introduction to Jane's life and family and documents the circumstances which led to her becoming pregnant, as well as her discovery of the pregnancy and the identity of the father.

### **Instrumentation**

**Moral imagination.** We operationalized moral imagination as the number of counterfactual scenarios participants were able to generate when confronted with six acts normally considered immoral or taboo. These scenarios were adapted from the Moral Judgment Task used by Black and colleagues (2017) to test the association of genre fiction exposure and moral permissibility judgments. Participants received the following instructions: "You will now be shown a series of scenarios. For each one, please generate as many circumstances as you can where the given scenario would be morally permissible." The scenarios (e.g., "Please list all the circumstances you can think of when it would be acceptable for a couple to kidnap an infant and raise it as their own child") were presented in random order with ten blank spaces underneath (see supplemental materials for details). Moral counterfactuals (MCF) were coded by three independent raters ( $r_{icc} > .99$  for all six scenarios). Unique MCFs were counted for each scenario and summed for a total MCF score ( $r_{\alpha} = .80$ ). Overall mean MCF was  $M = 7.45$  (median = 7,  $SD = 4.56$ ). We used all 25 items of the Moral Judgment Test in a pre-test to control for individual differences in moral permissibility, asking participants if it would ever be morally permissible to..., answered on a 4-point scale (*never, rarely, sometimes, always*;  $r_{\alpha} = .85$ ). See Table 2 for descriptive statistics by condition for all variables. All materials are available at [osf.io/7v2pt](https://osf.io/7v2pt).

**Creativity.** General creativity was assessed with the Alternate Uses Test (AUT; Guilford, 1967; see also Dippo, 2013). Often understood to assess divergent thinking, the AUT presents participants with everyday items and asks them to list all the ways in which these could

be used. The quantity of uses generated is believed to represent *fluency*, or the productivity aspect of divergent thinking (Reiter-Palmon, Forthmann, & Barbot, 2019). As such, it is best understood as a measure of creative potential, or the ability to generate ideas (Reiter-Palmon et al.), making it a good match for our MCF task. The AUT has been used to assess the effect of narratives on creativity (Morgan & Lewis, 2017), and makes similar imaginative demands as our moral counterfactual task. We used two tasks, the brick and the paperclip; underneath the picture and instructions (e.g., “Please list all the ways you can think of to use a brick such as the one pictured”) were 15 blanks. In order to match the moral imagination task, we used total number of unique uses generated, counted by three independent raters ( $r_{\text{Sicc}} > .99$ ). Participants who imagined more uses for one object also imagined more for the other,  $r(224) = .57, p < .001$ . A total score (brick + paperclip) was calculated for each participant to use in analyses ( $M = 9.36$ , Median = 9,  $SD = 3.73$ ).

**Transportation.** Green and Brock’s (2000) Transportation Scale was adapted for use in this experiment. Participants indicated the extent of their agreement with 13 items (e.g., “I was mentally involved in the narrative while watching the show,” and “I found myself thinking of ways events in the show could have turned out differently”), answered on a 7-point scale (*strongly disagree to strongly agree*). See Table 1.

**Experience with Science fiction.** Participants’ past experience with the genre of science fiction was measured in two ways. First, participants were asked to take a revised version of the Genre Familiarity Test (GFT; Black et al., 2017), an author checklist that asks participants to select names they recognize as authors from a list of real authors and fake names. This measure is modeled on the Author Recognition Test (e.g., Acheson, Wells, & McDonald, 2008; Stanovich & West, 1989), the aim of which is to measure exposure to written fiction in a manner that is

more immune to social desirability than asking participants how much and what they read. Thus, rather than asking participants to self-report their reading habits, the GFT takes as its premise that the more a person reads in a specific genre (such as sci-fi), the more likely they are to recognize the names of authors who write in that genre. In the modified version of the GFT used in this task, the sci-fi subscale of the GFT was expanded to include a total of 26 sci-fi writers ( $r_\alpha = .81$ ) out of 80 total names (real authors plus foils).

In addition to the GFT, participants were asked to complete twelve items that assessed their enjoyment of different genres (Mystery/Suspense, Romance, and Science Fiction). Four of these twelve items targeted sci-fi and were used to calculate a mean sci-fi enjoyment score. Example items include “I watch/read science fiction films, TV shows, and books on a regular basis” and “I find science fiction unpleasantly unrealistic and fanciful” (reverse-coded) were answered on a 5-point Likert scale.

### **Data analyses**

SPSS v24 was used for data cleaning and analyses. All continuous variables were tested for normality and, if not normally distributed, transformed prior to analyses. As per pre-registration, covariates were included in final models when  $p < .10$ . For Hypotheses 1a and 2a, ANCOVAs were used, predicting moral counterfactuals from condition and pre-test moral judgment and Creativity from condition, pre-test moral judgment, and sci-fi enjoyment. Hypotheses 1b and 2b were tested in regression models predicting Moral Counterfactuals and Creativity from pre-test Moral Judgment, sci-fi enjoyment (only used in H2b), condition, transportation, and the interaction between condition and transportation: the independent variable (condition: sci-fi vs. realistic vs. control) was dummy-coded (indicator method, with control as reference) and Transportation was mean-centered. The SPSS Macro PROCESS (Darlington &

Hayes, 2016) was used to test for and probe interactions; simple effects were tested at high, medium, and low levels of the moderator (transportation) set at 16<sup>th</sup>, 50<sup>th</sup>, and 84<sup>th</sup> percentiles. Effect sizes ( $d$ ) were calculated by dividing the mean difference by the root mean square error for the model. An ANCOVA predicting Transportation from condition and sci-fi enjoyment was used to test Hypothesis 3.

## Results

### Preliminary Analyses

Scores on the sci-fi Genre Familiarity Test (GFT) as well as total Moral Counterfactual (MCF) and Creativity scores were positively skewed and were corrected to normality with square root (GFT and MCF) and logarithmic transformations (Creativity) prior to use in correlational analyses. There was no difference between means across groups for the pre-test Moral Judgment Task,  $F(2, 223) = 0.07, p = .497, \eta^2 = .006$  (for all pairwise comparisons,  $ps > .250$ ). There were no differences in MFC ( $ps > .320$ ) or Creativity ( $ps > .210$ ) between the two sci-fi or realistic TV shows. There were no gender differences for Moral Imagination, Creativity, pre-test Moral Judgment, Transportation, or sci-fi enjoyment ( $ps \geq .124, ds \leq 0.25$ ), and gender and its interaction were not significant predictors in the Moral Imagination models ( $ps > .250$ ). Although GFT scores (sci-fi book exposure) were positively correlated with enjoyment of sci-fi ( $r = .19, p = .005$ ) and pre-test Moral Judgment ( $r = .16, p = .020$ ), they were not significantly related to transportation ( $ps > .400$ ) or the outcome variables ( $ps > .250$ ) in the ANCOVA models and were excluded from all final analyses. Mean transportation was highest for the Realistic TV ( $F(2, 223) = 10.32, p < .001, \eta_p^2 = .085$ ) compared with sci-fi ( $p < .001, d = 0.68$ ) and control ( $p < .001, d = 0.78$ ), which did not differ ( $p = .589, d = 0.08$ ). Descriptive



statistics and zero-order correlations by group for all variables presented in Table 2; details of nonsignificant effects in supplemental material (<https://osf.io/98bja/>).

### Primary Analyses

**Moral imagination.** Controlling for pre-test Moral Judgment, there were no differences amongst mean MCFs generated (sci-fi vs. realistic vs. control),  $F(2, 222) = 0.48, p = .617, \eta_p^2 = .006$  ( $ps \geq .348$  for all pairwise comparisons), thus H1a was not confirmed. The predicted interaction between Transportation and condition (H1b) was confirmed. Together, group (dummy-coded [indicator; control = 0] for analyses, with control as reference group), transportation, pre-test moral judgment, and the interaction between group and transportation accounted for 7.4% of the variance in Moral Counterfactuals,  $F(6, 219) = 2.94, p = .009$ . Higher scores on the pre-test moral judgment task were related to more counterfactuals generated,  $b = 0.47, 95\% \text{ CI } [0.10, 0.80], \beta = .17, p = .012$ . There were no main effects of condition or transportation ( $ps > .500$ ), but the overall interaction was significant, accounting for 2.8% of the variability in Moral Counterfactual generation  $R^2_{\text{CHANGE}} = .028, F(2, 219) = 3.27, p = .040$ . Although the relationship between transportation and counterfactual generation was not significant for the Realistic TV show group ( $b_{\text{interaction}} = 0.09 [-0.31, 0.40], \beta = .04, p = .662$ ), in the science fiction group, greater transportation into the narrative was associated with more counterfactuals generated,  $b_{\text{interaction}} = 0.36 [0.08, 0.60], \beta = .24, p = .013$ ). At low levels of Transportation (16<sup>th</sup> percentile), mean MCF score was significantly lower for the sci-fi group,  $t = 2.22, p = .027, d = 0.42$ ; there was no effect for Realistic TV ( $p = .952$ ). There were no significant differences at median or high levels of Transportation. See Table 3 and Figure 1.

**Creativity.** An ANCOVA predicting Creativity from pre-test moral judgment, sci-fi enjoyment, gender, and group revealed no differences between means,  $F(2, 220) = 1.85, p =$

.160,  $\eta_p^2 = .017$  ( $p \geq .058$  for all pairwise comparisons), thus H2a was not confirmed. The predicted interaction between transportation and condition (H2b) was confirmed. In the regression model, group (dummy coded for analyses, where control = 0, indicator), transportation, gender, pre-test moral judgment, sci-fi enjoyment, and the interaction between group and transportation together accounted for 12.1% of the variance in Creativity,  $F(8, 217) = 3.72, p < .001$ .<sup>1</sup> Higher scores on the pre-test moral judgment task were related to more alternate uses generated,  $b = 0.11, 95\% \text{ CI } [0.04, 0.19], \beta = .20, p = .002$ . Again, there were no main effects of condition or transportation ( $ps \geq .084$ ), and the higher order interaction was not significant at  $p < .05$ , although it accounted for 2.2% of the variability in Alternate Uses generation  $R^2_{\text{CHANGE}} = .022, F(2, 217) = 2.66, p = .072$ . Although the relationship between transportation and creativity was not significant for the Realistic TV show group ( $b_{\text{interaction}} = 0.03 [-0.04, 0.11], \beta = .07, p = .454$ ), in the science fiction group, greater transportation into the narrative was associated with more alternate uses,  $b_{\text{interaction}} = 0.06 [0.01, 0.12], \beta = .22, p = .022$ . Simple effects at low and median levels of transportation were not significant ( $ps > .05$ ), but at high levels, means for both the sci-fi ( $t = 2.22, p = .028, d = 0.53$ ) and realistic groups ( $t = 2.09, p = .038, d = 0.50$ ) were greater than that of the control group. See Table 2 and Figure 2.

**Imagination depletion.** Finally, we tested whether doing the creative and imaginative tasks before watching science fiction would decrease imaginative engagement in science fiction by comparing reported Transportation into the sci-fi narratives for the science-fiction group and control group. There was no evidence of imagination depletion: controlling for sci-fi enjoyment, means for experimental and control groups did not differ,  $F(1, 160) = 0.04, p = .846, d = 0.03$ .

## Discussion

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<sup>1</sup> Gender and enjoyment of sci-fi were included because they were significant at  $p < .10$ , as per pre-registration. Excluding them from the model does not change the results (for sci-fi,  $b_{\text{int}} = 0.06, \beta = .23, p = .020, sr^2 = .023$ .)

The purpose of this research was to test the effect of watching science fiction television on creativity, both with respect to moral imagination, operationalized as generation of counterfactual scenarios that would make normally taboo or immoral acts permissible, and general creativity, measured as amount of unique uses suggested for everyday objects (Guilford, 1967). Although there were no main effects of TV genre (sci-fi versus realistic) on either outcome variable, results supported our hypothesis of an interaction between condition and transportation for both moral imagination (Hypothesis 1b) and creativity (Hypothesis 2b). Whereas transportation was not related to subsequent creativity for participants who watched realistic TV, for participants in the sci-fi condition, less reported engagement with the narrative was associated with generating fewer moral counterfactuals and, similarly, fewer alternate uses on our test of general creativity. We also tested whether imagination for fiction could be depleted by prior use of the imagination (Hypothesis 3): there was no evidence that this was the case, as mean transportation for the sci-fi and control (who watched sci-fi *after* performing the moral imagination and creativity tasks) groups did not differ.

These results are noteworthy for several reasons. First, it is striking that the effect of transportation on our outcome variables exists only for sci-fi. Were it simply the case that individuals who are highly transportable at the trait level (see Dal Cin et al, 2014; Mazzocco, 2010) were also highly creative, we would have expected to see a similar pattern of results in the realistic TV condition, as well as in the control condition, where participants watched the same sci-fi stimuli as the sci-fi group, but completed the creativity tasks first. Given that this pattern of results was not found, why might transportation into sci-fi, specifically, have an effect on subsequent creative performance? One explanation involves the level of cognitive effort associated with the sci-fi genre. Although participants in both fiction conditions would have had

to expend effort to build mental models of the characters (Who are they? How can they be expected to act?) and the plot (What is happening? How does one event link causally to the next?), participants in the realistic fiction condition may not have had to expend as much cognitive effort on building a mental model of a story world that more closely resembled our own (e.g., Busselle and Bilandzic, 2008). In contrast, participants in the sci-fi condition, particularly those who did not achieve high, flow-like levels of transportation (Busselle & Bilandzic, 2008; Csikszentmihalyi, 1991; Green, 2004), may have had to expend more cognitive resources to track all of the ways that the sci-fi worlds depicted varied from our own. Notably, this possibility parallels research on pretend play in children that suggests that fantasy pretend play and realistic pretend play may differ in the cognitive demands they place on the pretender, with fantasy pretend play, in which children have to remember the rules of the fantasy and drastically shift between reality and pretense, being uniquely related to increases in executive function (e.g., Thibodeau, Gilpin, Brown, & Meyer, 2016).

The current experiment cannot distinguish whether the depletion effects found here would generalize to non-creative cognitive tasks, indicating a general depletion of cognitive resources, or whether participants who have difficulty becoming imaginatively absorbed in science fiction subsequently underperform only on tasks that require significant amounts of imagination. To this end, it is worth noting that we found the same general pattern of results across our two dependent measures, with transportation related to creative performance only in the sci-fi condition. Although the simple effects for the moral imagination and general creativity tasks diverged (see Figures 1 & 2), and the interaction effect was slightly stronger for moral counterfactuals, the pattern of results was the same for both, with less transportation meaning less creativity and vice versa but only for participants who had watched sci-fi. Future research is

necessary to explore whether there is a specifically moral component of the effect of sci-fi on creativity. Moral permissibility, an integral part of our moral imagination task, can also be assessed with simple rating tasks (Timmons & Byrne, 2018), thus avoiding direct demands on creativity. What is more, prior research has shown an effect of award-winning drama (vs. documentaries and control) on social cognition (Black & Barnes, 2015) in two experiments that did not include transportation and its interaction in the models: testing the effect of sci-fi and including narrative engagement could reveal an effect similar to that found in the present study, but only if the mechanism extends to social cognition. Even more intriguing would be to find an effect on *nonsocial* cognition that did not involve creativity, such as working memory or processing speed.

Indeed, future research is needed to investigate the role that task difficulty played in these results on multiple levels. Although we found no evidence of imagination depletion for participants in the control condition, who watched the sci-fi shows after completing the moral imagination and general creativity tasks, it is possible that this null result is a reflection of the particular tasks used, which allow participants to determine the number of moral counterfactuals and creative uses generated. Because participants identify their own stopping point, it could be that most choose to stop before the task becomes overly effortful or stretches their imagination in a significant way. Future research should investigate whether more difficult imaginative tasks, or tasks that require a certain level of imaginative performance, yield different results. What is more, we operationalized general creativity with the Alternate Uses Task, which made a good match for the moral imagination task, but is better thought of as a measure of creative potential within divergent thinking, rather than general creativity (Reiter-Palmon et al., 2019), especially given that our instructions asked for quantity and we only scored the number of unique

responses. The task can also be scored on other dimensions, such as originality and flexibility: it would be interesting to adapt the instructions and score the task accordingly in order to test the effects of sci-fi on other dimensions of divergent thinking.

Similarly, future research is needed to investigate the degree to which the effects found here are due to differences in the overall difficulty of becoming transported into realistic fiction and sci-fi. In the current experiment, there were mean differences in transportation across the sci-fi and realistic television show conditions; participants reported being more transported into the realistic shows than the sci-fi shows. In some ways, this is unsurprising: to the extent that transportation involves mentally traveling from the here and now to the story world, we would predict that stories further removed from our world would present greater transportation challenges. Nonetheless, further research is needed to investigate not only self-reported transportation into sci-fi, but also the degree to which low levels of transportation in sci-fi reflect the difficulty of becoming absorbed versus a lack of motivation to lose oneself in an unrealistic story. It is possible that the interaction between condition and transportation here is the result of participants who were unmotivated to imaginatively engage with sci-fi carrying over this lack of motivation to subsequent imaginative tasks. Contrastingly, it could be that the cognitive demands of following a sci-fi story when you are not transported depletes imagination in a way that simpler tasks, such as following a realistic story or completing the alternate uses or moral imagination tasks used here, do not. Future research could shed light on these possibilities by asking participants to rate the difficulty each task and by comparing creative performance after watching sci-fi and realistic dramas that are equally transporting.

Notably, if the results found here reflect the level of cognitive difficulty associated with the sci-fi narratives, then we would expect that similar effects might also be seen with other

genres, such as fantasy and historical fiction, which also take place in worlds that differ significantly from our own, as well as for more challenging, “literary” fiction, where building models for more complex characters may require more of the audience (e.g., Kidd & Castano, 2017). Future research is also needed to examine whether there is variation within the sci-fi genre. The stimuli chosen for this experiment were selected because they were largely unknown to our undergraduate sample and center on popular sci-fi motifs (time travel and interplanetary travel/spaceships), but vary significantly on other characteristics, such as tone, setting, protagonist gender, and subgenre. Although our selection criteria allowed us to cover a wider breadth of the genre, it is worth noting that neither *Firefly* nor *Continuum* fit what might be seen as prototypical (or perhaps stereotypical) sci-fi. *Continuum* begins in the future, but is set largely in the present day; *Firefly* plays with and subverts many popular tropes surrounding space travel and futuristic technology and is written largely as a Western that happens to be set in space. One intriguing possibility for future research is that the significant interaction effect found here may have less to do with differences in genre (i.e. science fiction versus realistic fiction) than with differences in how closely a given narrative adheres to the expectations and schema for that genre. Perhaps *Jane the Virgin* is, despite its implausible premise, a more typical telenovela-style soap and *Castle* a more typical police procedural than *Firefly* and *Continuum* are for sci-fi. Given that it has been suggested that audiences use schemas of both the real world and prior genre experience to scaffold the building of mental models for narratives (Busselle and Bilandzic, 2008), this is an area ripe for future research. Interestingly, in the current study, although self-reported enjoyment of sci-fi was significantly related to transportation into both realistic and sci-fi narratives, prior experience with sci-fi in books was not related to transportation into the narratives. This result is particularly striking given that, in theory, those

who have more well-developed schema for the sci-fi genre in general should have an easier time building cognitive models for the story worlds they encountered in the sci-fi condition (see Busselle & Bilandzic, 2008, for discussion of the role of genre in building cognitive models). One limitation of the current research is that we did not include a measure of prior experience with science fiction television or movies; future research is needed to investigate the possibility that prior experience with the sci-fi genre across media may impact transportation and, subsequently, creativity, and to investigate whether stories that closely adhere to genre expectations yield different results than those that do not.

Another important limitation that merits future research involves the demographics of the sample, which consisted of college undergraduates (92.5% under the age of 21) and skewed heavily female (81.9% of the final sample). Although gender distribution was even across conditions and we found no statistically significant gender differences on any outcome variable or covariate, the preponderance of females in the current sample is nonetheless worth noting, particularly given that at least one of our stimuli (*Jane the Virgin*) skews heavily toward a female demographic. Although not a focus of the current experiment, which included as stimuli one show that had a male protagonist and one that had a female protagonist in each condition, future research with a more even gender distribution in the sample may be able to probe any interactions that exist between genre, protagonist gender, and participant gender. Similarly, samples that include a wider range of ages may further elucidate the role that knowledge of and experience with the sci-fi genre plays in scaffolding transportation into sci-fi stories. With a wider range of prior experience with the genre, lifetime exposure to written sci-fi might be a significant predictor.



It should also be noted that in both regression models, our predictors only explained a small proportion of the variability in the outcome variables. The unexplained variance may be due entirely to individual differences, or there may be some aspects of interaction with fiction that we did not capture in our model but could affect outcomes, such as identification with the characters (Vezzali, Stathi, Giovannini, Capozza, & Trifiletti, 2014) or moral disengagement (Sanders & Tsay-Vogel, 2016), which may be particularly relevant for our moral imagination task.

To conclude, this study makes an important first step into investigating the association between imagination and fiction and suggests many avenues for future research. Past correlational research showed an association between cumulative exposure to written sci-fi and participants' tendency to report that the possible could become impossible and that the immoral could, in some circumstances, be moral; however, using an experimental design, we found no main effect of exposure to sci-fi on subsequent performance on imaginative tasks. Rather, it appears that *how* one engages with sci-fi matters. Results suggest that viewing sci-fi has a unique effect on creativity—including moral imagination—that depends on the cognitive effort needed for fictional engagement. Our choice of outcome variables also constitutes an important contribution to the literature that has the potential to better address cognitive mechanisms. Unlike most experimental research on the effects of fiction, which use self-report measures (Bal & Veltkamp, 2013; Mara & Appel, 2015) or performance on a multiple-choice task (Black & Barnes, 2015; Kidd & Castano, 2018; Panero et al., 2016; Samur, Topps, & Koole, 2017), our open-ended response tasks required active engagement and cognitive effort. The moral counterfactual task was chosen because engagement with sci-fi worlds requires the ability to make mental models that allow for different moral paradigms as well as currently unrealistic

technologies. Moral counterfactual generation could be an appropriate outcome to test the effects of literary fiction, which tends to include morally ambiguous protagonists (Black et al., 2017); alternatively, it would be interesting to explore the effects of fantasy on both counterfactual generation and general creativity. Although fantasy requires readers/viewers to engage with arguably more unrealistic worlds (magic, dragons) than science fiction, the popularity of the fantasy genre (e.g., *Harry Potter*, *Game of Thrones*) raises the question of whether transportation into worlds that *don't* purport to be grounded in real-world science is somehow easier than those that do. Testing the ease with which viewers engage with fantasy vs. sci-fi, and exploring the moderating of transportation on the effects of condition across different genres would be an important follow-up study.

The data and materials (in preregistration) for this experiment are available at <https://osf.io/xs7b3/> which was preregistered prior to data collection (<https://osf.io/c2k36/>). Only *a priori* hypotheses were tested in accordance with preregistration.

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Table 1

*Hypotheses and variables.*

Hypothesis 1	<i>Does watching science fiction affect moral imagination?</i>	
Independent variable:	Viewing sci-fi, realistic TV, or control group.	
Outcome variable:	Number of Moral Counterfactuals (MFCs) generated	
H1a (main effects)	There will be a difference in MFCs between conditions (sci-fi, realistic TV, control)	Not confirmed
H1b (interaction)	In the sci-fi group only, transportation will be positively correlated with MFCs	Confirmed
Hypothesis 2	<i>Does watching science fiction affect general creativity?</i>	
Independent variable:	Viewing sci-fi, realistic TV, or control group.	
Outcome variable	Number of alternate uses for a brick and a paperclip generated.	
H2a (main effects)	There will be a difference in alternate uses generated between conditions (sci-fi, realistic TV, control)	Not confirmed
H2b (interaction)	In the sci-fi group only, transportation will be positively correlated with number of alternate uses generated	Confirmed
Hypothesis 3	<i>Can imagination for fiction be depleted?</i>	
Independent variable:	Prior imaginative work (control group completed tasks prior to viewing sci-fi)	
Outcome variable:	Scores on the Transportation Scale	
H3	There will be a difference in reported transportation between the sci-fi and control groups.	Not confirmed.

*Note.* All participants were randomly assigned to view sci-fi, realistic fiction, or to a control group that completed the outcome variable tasks prior to viewing the same shows that the sci-fi group saw.

Table 2.

*Descriptive statistics and zero-order correlations between Moral imagination (number of counterfactuals generated), Moral Judgment pre-test, Creativity (Alternate Use Test; Guilford, 1967), and Transportation into the narrative by group.*

	$\alpha$	M	SD	Median	Pre-test Moral Judgment	Creativity	Transportation	ES-F
<b>Control</b>								
Moral imagination	.70	7.52	4.41	7.00	.22 [-.003, .42]	.32 [.06, .52]**	-.03 [-.26, .18]	.06 [-.14, .25]
Pre-test Moral Judgment	.90	1.57	0.31	1.52	--	.18 [-.03, .37]	.17 [-.10, .44]	.28 [.08, .48]*
Creativity	.64 <sup>a</sup>	8.74	3.05	8.00		--	-.04 [-.22, .16]	.13 [-.11, .34]
Transportation	.88	4.09	0.94	4.21			--	.46 [.27, .62]***
Enjoyment of sci-fi (ES-F)	.77	4.39	1.24	4.25				--
<b>Science fiction</b>								
Moral imagination	.78	7.11	4.90	6.00	.05 [-.10, .19]	.50 [.34, .63]***	.29 [.02, .52]**	.23 [.03, .42]*
Pre-test Moral Judgment	.80	1.61	0.29	1.60	--	.17 [-.03, .36]	-.10 [-.31, .10]	.07 [-.14, .28]
Creativity	.80 <sup>a</sup>	9.35	3.75	9.00		--	.25 [.01, .48]*	.22 [.03, .41]*
Transportation	.82	4.16	0.95	4.21			--	.40 [.22, .58]***
Enjoyment of sci-fi (ES-F)	.78	4.54	1.36	4.50				--
<b>Realistic</b>								
Moral imagination	.80	7.86	4.26	7.00	.21 [-.03, .43]	.20 [-.06, .44]	.03 [-.22, .28]	.03 [-.23, .30]
Pre-test Moral Judgment	.83	1.63	0.32	1.56	--	.27 [-.06, .53]	.01 [-.22, .24]	.24 [-.02, .45]
Creativity	.66 <sup>a</sup>	10.10	4.31	9.00		--	.12 [-.10, .33]	.16 [-.05, .35]
Transportation	.83	4.71	0.61	4.79			--	.40 [.14, .61]***
Enjoyment of sci-fi (ES-F)	.84	4.62	1.29	4.75				--

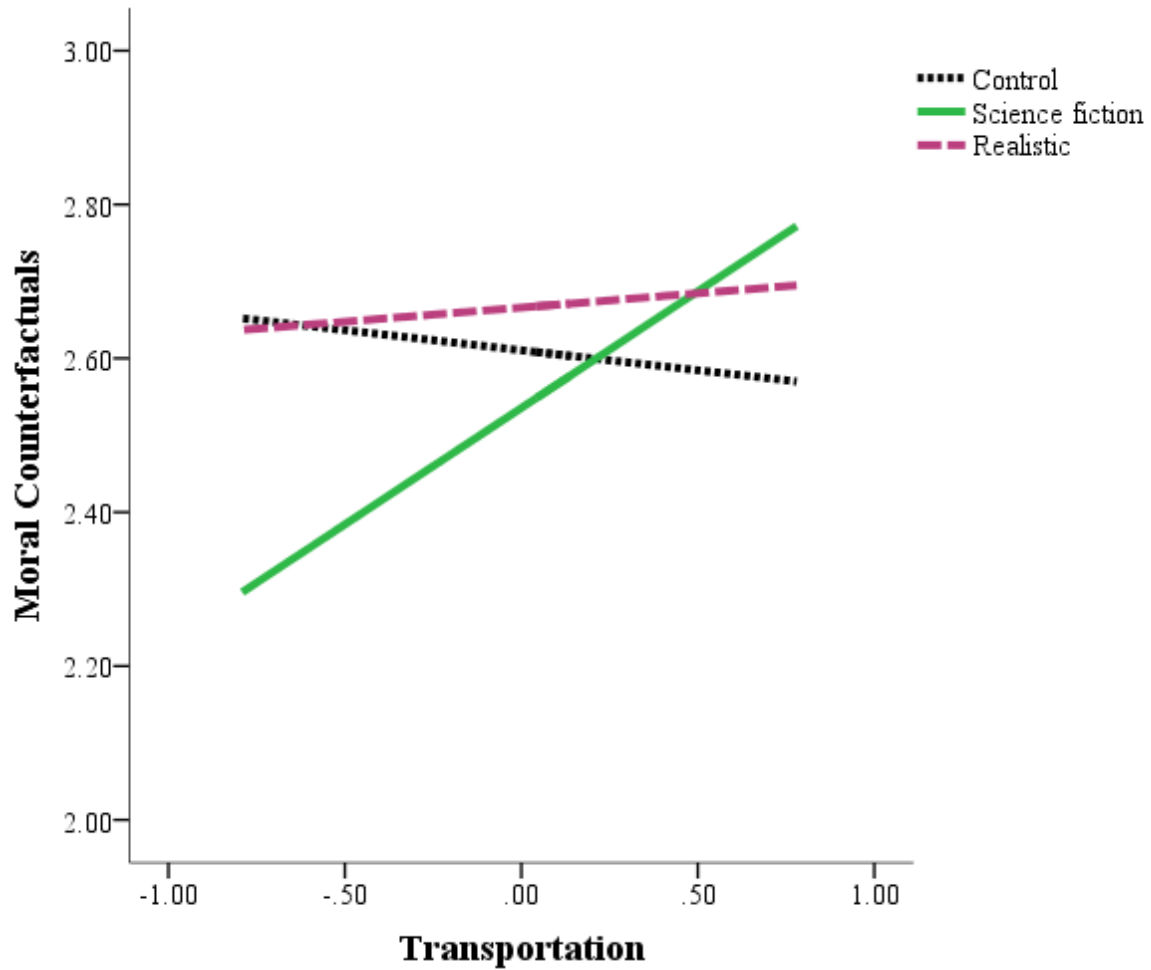
*Note.* <sup>a</sup>For creativity, correlation between two variables (brick and paperclip) reported in alpha column.

Table 3.

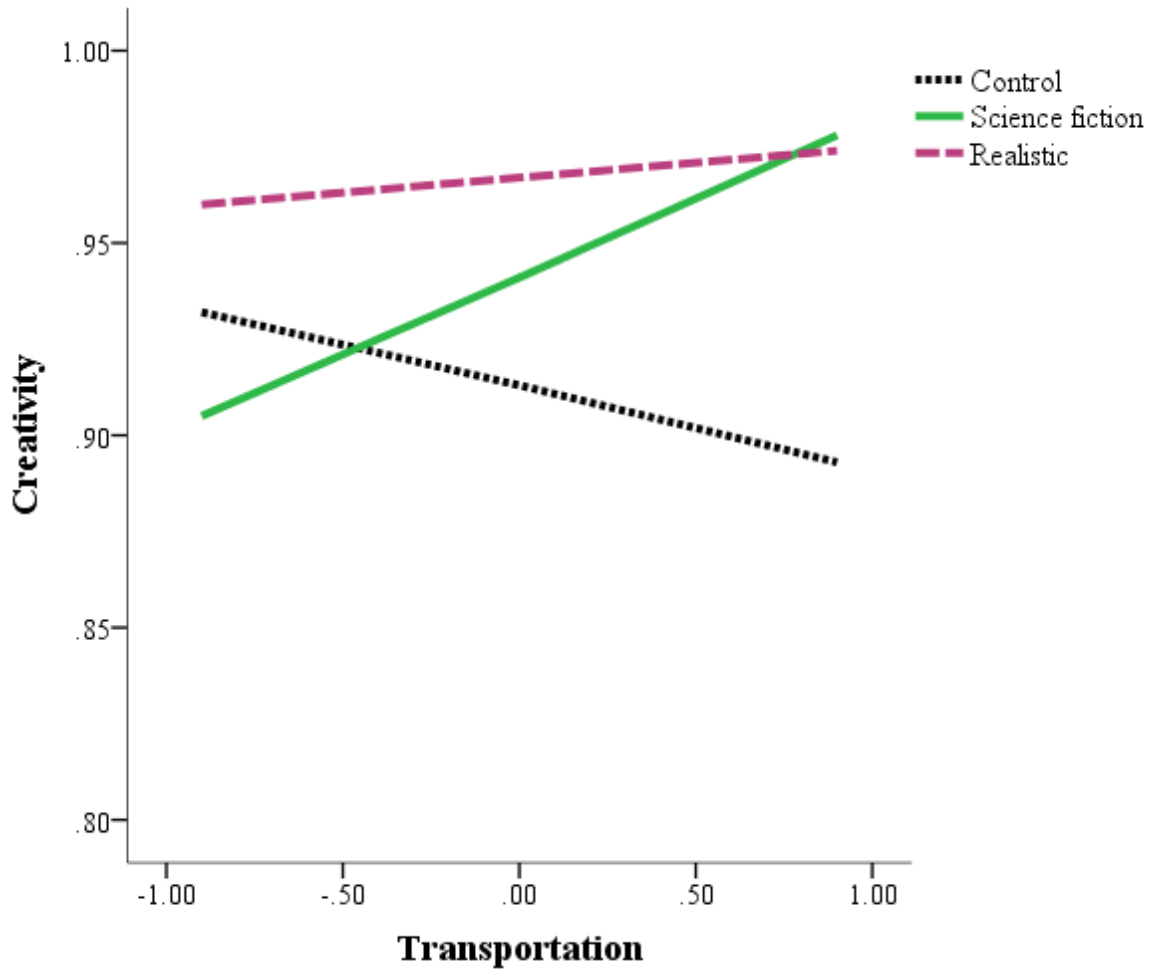
*Regression models testing for interactions between condition (control vs. science fiction vs. realistic TV shows) and Transportation for Moral Imagination and Creativity.*

Predictors	<i>b</i>	$\beta$	<i>sr</i> <sup>2</sup>	<i>p</i>
<b>Moral imagination</b>				
Pre-test Moral Judgment	0.47	.166	.027	.012
Dummy var A sci-fi = 1	-0.08	-.042	.001	.579
Dummy var B Realistic = 1	0.06	.029	.001	.736
Transportation (TS)	-0.05	-.055	.001	.616
Overall TS*condition			.028	.040
TS*Dummy A	0.36	.244	.026	.013
TS*Dummy B	0.09	.038	.008	.662
		$R^2_{\text{MODEL}} =$	.074	.009
<b>Creativity</b>				
Gender	0.06	.125	.015	.054
Pre-test Moral Judgment	0.11	.204	.039	.002
Sci-fi enjoyment	0.02	.121	.011	.093
Dummy var A sci-fi = 1	0.03	.084	.005	.263
Dummy var B Realistic = 1	0.05	.145	.012	.084
Transportation (TS)	-0.02	-.116	.004	.294
Overall TS*condition			.022	.071
TS*Dummy A	0.06	.220	.022	.022
TS*Dummy B	0.03	.065	.002	.454
		$R^2_{\text{MODEL}} =$	.121	< .001

*Note.* Moral imagination operationalized as number of unique moral counterfactual scenarios generated. Creativity operationalized as total number of unique uses listed for the Alternate Uses Test (brick and paperclip).



*Figure 1.* Effect of Condition\*Transportation interaction on Moral Imagination. For participants in the science-fiction condition, greater transportation into the narrative resulted in the generation of more counterfactuals. There was no effect for those who watched realistic TV or the control group. (MCF variable transformed prior to analyses.)



*Figure 2.* Effect of Condition\*Transportation interaction on general creativity. Participants in the science-fiction group who felt more transported into the narrative tended to generate more possible alternate uses for a brick and a paperclip. There was no interaction effect in the realistic TV group. Number of Alternate uses variable transformed prior to analyses.