Running Head: SCIENCE FICTION AND TECHNOLOGY

Meaning Through Fiction: Science Fiction and Innovative Technologies

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Paper accepted for publication in the journal

Psychology of Aesthetics, Creativity, and the Arts

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Abstract

Connecting philosophical and psychological theories on meaning to theories and findings on the real-world influence of fictional stories, the authors argue that science fiction provides meaning for otherwise disconcerting new technologies. An experiment with two points of measurement was conducted. After watching a full-length movie with a humanoid robot in a main role (vs. a control film condition) participants had a clearer understanding of humanoids. This in turn was related to a stronger link between the concept of humanoid robots and the self, which predicted a higher willingness to buy or use humanoid robot technology. The results remained stable after a two-week post-exposure delay. Implications regarding the meaning-generating function of fiction, science fiction, and humanoid robots are discussed.

Key Words: meaning, science fiction, stories, narratives, humanoid robots, mediation

Meaning through fiction: Science fiction and innovative technologies

Questions regarding the real-world implications of recipients' immersion into fictional story worlds have fuelled numerous empirical studies in recent years. Adding to this thriving literature we argue that a major function of fiction is to provide meaning for otherwise unsettling real-world phenomena. Our empirical focus here is on science fiction – a genre that like no other challenges its recipients to envision the unkown and that was hitherto largely neglected by empirical research.[1]

The influence of science fiction on peoples' contemporary, earthly life is an intriguing topic not only for social scientists but for the hard sciences and the humanities as well. Prior to their adoption by people and societies, many technological innovations already have a life in the world of fiction. Flying machines, space-rockets, and submarines, for example, existed in the fictional worlds of Jules Verne many years before they were invented in real life (e.g., *From Earth to the Moon*; *Robur the Conquerer*; *Twenty Thousand Leagues under the Sea*). There are a number of other examples where science fiction versions of technologies preceded real-world innovations (e.g., radar, TV, cf. Gernsback, 1911 / 2000). Arguably, due to their interest (and professional background) in

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[1] Science-fiction is defined along five typical story components outlined by renowned science fiction author Robert A. Heinlein (1947/1964): "1. The conditions must be, in some respect, different from here-and-now, although the difference may lie only in an invention made in the course of the story. 2. The new conditions must be an essential part of the story. 3. The problem itself—the "plot"—must be a *human* problem. 4. The human problem must be one which is created by, or indispensably affected by, the new conditions. 5. And lastly, no established fact shall be violated, and, furthermore, when the story requires that a theory contrary to present accepted theory be used, the new theory should be rendered reasonably plausible and it must include and explain established facts as satisfactorily as the one the author saw fit to junk."

technology and the sciences, science fiction writers might be capable of forecasting future developments (although many prophecies were incorrect). However, science fiction might as well have a causal influence on real-life technological innovation. Unfortunately, there is much anecdotal, but little empirical evidence available in this regard.

We can think of at least two causal pathways as to how technologies introduced in science fiction could potentially affect the technologies we have in real-life: First, works of science fiction could affect inventors and scientists – either because science fiction provided helpful information or, more likely, because science fiction motivated individuals to delve into a particular problem or to pursue a scientific career in the first place. Crouch (1982), for example, provides intriguing case studies about pioneers in aeronautics and the inspiration they gained from fictional accounts of interstellar travel. More recently, Bailenson, Yee, Kim, and Tecarro (2007) outlined how cyberpunk science fiction (e.g., Gibson, 1984; Stephenson, 1992) triggered research questions for virtual reality researchers and how cyberpunk delineated standards in the development of virtual reality systems.

Second, science fiction could potentially affect those who are confronted with new technologies and who often decide about the failure or success of an innovation: the ordinary consumer, recipient, or citizen. This paper deals with the latter causal pathway. Based on a general assumption on the meaning-generating effect of narratives, we hypothesize that a science fiction film featuring a humanoid robot provides meaning to this otherwise alien technology – humanlike service robots – which in turn increases the acceptance of this robot.

Robots in our midst

According to the International Federation of Robotics (2014), about 180,000 units of industrial robots were sold in 2013, by far the highest number ever recorded. Most of these robots went into automotive manufacturing, chemical and plastic industries, or food production. Recently, however, big tech companies also started to announce their robot visions for areas beyond industrial application: Amazon puts much effort in the development of autonomous delivery drones (Wingfield, 2015), Google forecasts their robot cars to chauffeur passengers by 2020 (Halleck, 2015), and iRobot, best known for its vacuuming bots, plans to expand into the health care sector (Solomon, 2013). In addition, robots for personal and domestic usage are expected to become more and more prevalent. The consumer demand for different types of social and service robots seems to be there. MIT's Jibo, a companion robot that is able to read stories or shoot family portraits, raised about 2.3 million US-Dollars from several thousand private investors in 2014 and became one of the most successful online crowdfunding campaigns (Hurst, 2014). The Japanese telecommunications brand Softbank introduced a social robot that can analyze its users' emotions for a market price under 2,000 USD (Pfanner, 2015), and Intel presented a customizable personal robot that shall be sold for under 1,000 USD (Collins, 2014). But also more specialized domestic robots for elderly and handicap assistance are expected to increase substantially within the next two decades (International Federation of Robotics, 2014). Regarding their design, some of the robots that we are going to meet in our day-to-day lives will have an abstract machine-like look, but others will correspond more strongly with the typical robot image of humanlike shape. When it comes to the latter, a distinction can be drawn between the *android* and the *humanoid*: Whereas android robots are intended to mimic human appearances as realistically as possible, humanoid robots only basically

resemble the human body shape but are easily recognizable as machines, e.g. due to their clearly artificial surfaces (cf. Ishiguro, 2005).

Today, however, still only rare opportunities allow for real-life encounters with humanlike service robots. Science fiction, in contrast, is full of humanoid and android figures. Examples reach from early fictional characters such as Rossum's Universal Robots (Čapek, 1920/2001) — a Czech stage play from which the term *robot* originated — to more contemporary and highly popular figures such as Star Trek's Lieutenant Commander Data (Roddenberry, 1966), Star Wars' C-3PO (Lucas, 1977) or the misanthropic Bender from the animated TV series Futurama (D. X. Cohen & Groening, 1999). Thus, science fiction might be a frequent source of information about humanlike robots for the public today.

The processing and the effects of fiction and empirical evidence regarding science fiction

In recent years, a substantial number of studies have examined the influence of fictional stories on recipient variables, including recipients' knowledge about real-world issues (e.g., Dahlstrom, 2012; 2014; Marsh, Meade, & Roediger, 2003), attitudes and beliefs (e.g., Appel & Richter, 2007, 2010; Green & Brock, 2000), behavioral intentions (Appel & Mara, 2013), the self-concept (e.g., Djikic, Oatley, Zoeterman, & Peterson, 2009; Richter, Appel, & Calio, 2014), and the theory of mind (e.g., Fong, Mullin, & Mar, 2013; Kidd & Castano, 2013). The influence of stories is often attributed to the particular experiential state while reading, listening to, or watching a story. This phenomenological characteristic of reading a story or watching a movie is the absorption and lack of distance, the involvement that recipients often experience. Different terms have been used to describe and explain experiential states during media use. This family of concepts on

situational involvement can be distinguished into narrative involvement/transportation on the one hand and character involvement/identification on the other (Moyer-Guse, 2008; Murphy et al., 2011; Nabi & Green, 2015). Narrative involvement includes the concept of transportation (Gerrig, 1993; Green & Brock, 2000) as well as related concepts such as narrative engagement (Busselle & Bilandzic, 2009), and flow. Character involvement includes identification (J. Cohen, 2001), perceived similarity/homophily, empathy, sympathy, and para-social interaction. Although narrative involvement and character involvement share similarities, they are generally considered to be conceptually distinct (e.g., Tal-Or & J. Cohen, 2010).

Research on narrative experiences and effects is typically focused on stories set in the here-and now (e.g. Murder at the Mall: Green & Brock, 2000; Appel & Maleckar, 2012; The Kidnapping: Prentice, Gerrig & Bailis, 1997). Do the effects and processes differ when it comes to science fiction? There is initial evidence that science fiction stories might indeed yield different processes and effects. In a recent correlational study (Fong et al., 2013) the science fiction/fantasy genre somewhat stood out as the only one in which the relationship between fiction reading and interpersonal sensitivity was unrelated (controlling or not controlling for third variables). Several studies found that readers of fictional stories use correct and incorrect information embedded in the story in a quiz about real-world issues following closely after reading (e.g., Marsh et al., 2003). With respect to these findings Rapp and colleagues observed that many studies in this paradigm used fictional, but rather familiar situations as the narrative contexts (Rapp, Hinze, Slaten & Horton, 2014). They wondered whether the reliance of information presented in a fictional context changed if the context was less familiar, like in a fantasy or science fiction story (Rapp et

al., 2014; see also Zwarum & Hall, 2012). Thus, Rapp and colleagues manipulated the story worlds surrounding the target information. They demonstrated that information encountered in a fantastic story context was used to answer real-world questions – but to a lesser extent than information encountered in a more mundane story context. Possibly, a science fiction or fantasy setting enables recipients to more effectively compartmentalize fictional information from real-world knowledge (Gerrig, 1993).

The only experimental study that explicitly dealt with science fiction and robots (Mara & Appel, 2015) focused on the uncanny valley hypothesis (Mori, 1970), which assumes a non-linear relationship between the human-likeness of a robot and people's evaluation of that robot: At low levels of human-likeness, the more robots resemble humans, the more positive they are perceived. At some point of high similarity but not perfect resemblance, however, the perception will sharply drop and the robot will be perceived as eerie and uncanny. When the robot is almost perfectly human, the evaluation turns positive again (Mori, MacDorman, & Kageki, 2012). Participants who read a brief story about a robot reported less eeriness than participants who read a non-narrative leaflet about the robot, an effect that was mediated through the perceived human-likeness of the robot (Mara & Appel, 2015).

The work presented here contributes to the literature on the influence of fictional stories by emphasizing the meaning-generating function of fiction (see more below). We assume that a fiction film featuring a humanoid robot clarifies the concept of humanoid robots for the recipients. It connects the concept with one's self and in turn increases the acceptance of humanlike robots. Before we explain our stance on the meaning generating function of science fiction, a brief section on *meaning* seems justified.

Meaning

Since the seminal works by Oliver and colleagues (e.g., Bartsch, Kalch, & Oliver, 2014; Oliver & Bartsch, 2010; Oliver, Hartmann, & Woolley, 2012) research on meaningful media has become a flourishing topic in empirical research (e.g., Koopman, 2014; 2015; Rieger et al., 2015). Our own approach to the concept of meaning is informed by philosophical treatments on men's search for meaning (Camus, 1942/1955; Frankl, 1946/1959; Heidegger, 1927/1996) as well as the meaning maintenance model, a psychological theory aimed at integrating previous theory and empirical findings (Heine, Proulx, & Vohs, 2006). So what is meaning? Meaning is relation – "meaning is what links people, places, objects, and ideas to one another in expected and predictable ways" (Heine et al., 2006, p. 89). These expected relationships of things can be found (or not found) in three domains: The outside world, the self, and the self in the outside world.

The outside world includes all non-self entities, like objects, people or places. People develop representations of the outside world with relatively stable and coherent features (e.g., schemata, concepts, scripts, mental models). For technological innovations – like airplanes in the early 20th century, or tomorrow's autonomous cars or humanlike robots – a working representation is often inexistent. The self is the second domain in which the sense of meaning is based on expected relationships between elements. People wish to perceive themselves as incorporating a non-contradictory set of attributes, and people wish to act in a consistent and predictable manner (Abelson, 1968; Festinger, 1957). The third domain is the self in the world. A person can perceive the world as well as oneself to entail a set of expected relationships between elements, but he or she may lack the sense of a coherent relationship between oneself and the world. This lack of meaning is likely a cause

of feelings of non-belonging and alienation. Technological innovations can be a source for alienation as these might fit perceptions of the world outside (as a technology driven or market-oriented space) but the connection between one's sense of self and the outside world is perceived to be missing. Being confronted with a lack of relationships in any of the three domains (outside world, self, self and the outside world) is aversive.

Stories generate meaning

Fictional stories often deal with topics that pose a challenge to our meaning systems. Many stories, for example, portray characters in major life transitions and many stories deal with questions of suffering and death (cf. Koopman, 2015). Although science fiction may include similar dramatic content, its specific appeal to our meaning systems rests on the new scientific developments and the unfamiliar technologies that are portrayed. Within the genre, a common distinction is drawn between hard and soft science fiction. The former adheres to the laws of nature and usually portrays a technology that is based on real scientific theories or already existing technological trends (cf. Prucher, 2007; Samuelson, 2009). The latter is a term that is either used when future developments are portrayed more from a social science perspective (e.g., from a political or sociological perspective) or when scientific elements play only a minor role (soft science fiction is also sometimes used as a pejorative term indicating that the science behind the story is implausible). In addition, science fiction stories can be differentiated according to the timeframe in which they are set. Near-future science fiction is meant to depict a story world that still appears connected to the here-and-now of its recipients. In contrast, far-future sci-fi may be set in an era beyond the 10^{th} millennium and take up issues such as humankind's final days on Earth.

We assume that literary representations of the near future, particularly if they involve innovations based on today's scientific understanding and technology are especially relevant in order to establish meaning for a world in which we will live one day, or for a technology that we might be confronted with in our lifetime. Theorists from several fields have considered stories to be a main source to establishing meaning (e.g., Bruner, 1990; McAdams, 1996; Polkingthorne, 1988; Sarbin, 1986). Humans tell themselves stories whenever meaning is threatened, like at times of failure and grief (cf. Gilbert, 2002). Stories are a natural way to explain things as they fit our cognitive architecture (Gottschall, 2012; Schank & Abelson, 1995). Per definition (e.g., Abbott, 2002), stories consist of *related* events. Almost all stories on TV and in the movies further adhere to conventions in the formation of a plotline (e.g., Howard & Marbley, 1993). Stories entail schematic elements (cf. e.g., setting, event, attempt, reaction, and consequence, Rumelhart, 1975) that are connected to the characters' goals. Stories on TV and in the movies tend to have a resolution in which the threads laid out during the story are re-connected. Guides to scriptwriting for TV and film further emphasize that the events need to be based on the characteristics of the protagonists. Thus, these events are expectable or even inevitable – at least in hindsight (Howard & Marbley, 1993). The expectable events in fiction diverge from the often random events occurring in real life (Appel, 2008). The meaning-generating function of stories is reinforced by the recipients' tendency to be immersed into the story, as expressed by concepts in the fields of narrative and character involvement. The lack of a distance between the recipient and the story-world can contribute to a connection between one's self and the things and events belonging to the fictional world.

Taken together, the narrative structure and the plot conventions facilitate perceptions of coherence and relatedness in the world around us. Moreover, recipients are often deeply immersed and engaged with the story world, leading to a strong relationship between the self and the fictional entities. Entering the world of science fiction can allow recipients the development of meaning frameworks for future technologies that otherwise would make no sense or lead to feelings of alienation. Science fiction imposes a clearer understanding about what to expect from a future technology and it connects the recipient's self to the new technology.

Study overview and predictions

The aim of this study was to examine the meaning-generating function of science fiction regarding humanlike robots. We presented a full-length science fiction movie that featured a humanoid as a main character (or a control movie). We expected that this movie would change the meaning framework of humanoids in two ways. The movie should establish a clearer concept of the humanlike robot among the recipients. Moreover, recipients were expected to develop a closer link between the concept of humanoids and themselves. Changes in these meaning frameworks were in turn expected to contribute to positive behavioral intentions towards humanlike robots (i.e., to consider using humanoid service robots in the future). We further expected that the effect of the science fiction film would not be short-lived, but would remain after a delay of two weeks (cf., Appel & Richter, 2007; Jensen et al., 2011). Thus, the study needed to contain a two-weeks post-exposure assessment in addition to an immediate post-exposure assessment.

Method

Sample size considerations and participants

We determined the number of participants a priori to reach at least 25 participants per cell which is in line with the recommended minimum number per cell of 20 to prevent false positive outcomes (Simmons, Nelson, & Simonsohn, 2012). Based on a one-factorial design with two experimental conditions our a priori number of participants was fifty. Although this sample size is well within the number of participants found in much of the experimental psychological research, it is arguably rather low. Our procedure included a main experimental session of about two hours and a delayed survey. The envisaged sample size reflects the practical challenge of recruiting motivated participants, given the two session design and the length of session one. Our experimental design included two mediating variables (see below). Recent research on mediation suggests that the power to detect indirect effects is typically *larger* than the power to detect direct effects or total effects, a somewhat counterintuitive phenomenon introduced as a *power anomaly* (Kenny & Judd, 2014). Thus, from a power perspective, the mediation part of our design did not require a higher number of participants than a more simple main effects experimental design.

To account for individuals who might not participate in both sessions, we planned to invite at least 60 individuals to participate. Sixty-five adults were recruited in introductory social science classes at the (*blinded for review*). Three participants did not complete the delayed survey part, six participants had watched or had heard about one of the stimulus films before. After excluding these data our sample consisted of 56

participants (41 women; age range 18-33, *M* = 21.30 years; *SD* = 2.27). The participants received course credit or participated in a lottery to win one out of five 10€ gift certificates.

Stimulus films

The participants were randomly assigned to watch one out of two movies. One movie, *Robot and Frank* (Schreier, 2012) included a humanlike robot as a main protagonist. The movie takes place in the near future of industrialized civilizations and is about the friendship between the slightly demented Frank, an aging jewel thief, and his service robot (*n* = 29). The movie portrays a robotic technology resembling contemporary concepts for service robots, thus, Robot and Frank exhibits important characteristics of hard science fiction. Moreover, the movie focuses on the emotional bonding between man and machine, which is in line with the definition of science fiction introduced earlier (Heinlein, 1947 / 1964). In the control condition (*n* = 27) the movie *Safety Not Guaranteed* (Trevorrow, 2012) was presented. This movie is about three journalists, who are assigned to interview a time machine inventor. Both movies shared several characteristics: Both movies were released in summer 2012, they have a similar duration (*Robot and Frank*: 89 minutes; *Safety Not Guaranteed*: 86 minutes), both movies belong to the science fiction genre and are set in the near future, and both movies had an equivalent rating on IMDb in summer 2014 (both movies scored 7.1). Moreover, both movies were relatively unknown. Importantly, both movies differed with regard to the presentation of humanlike robots: Whereas *Robot and Frank* showed how a future service robot might assist an elderly person, the topic of robotics was irrelevant for the control movie.

Measures

Transportation. Participants answered the Transportation Scale – Short Form (TS-SF, Appel, Gnambs, Richter, & Green, 2015). In our sample, the reliability of this six-item scale was satisfactory (α = .78). The items went with a seven-point scale (example items: "I could picture myself in the scene of the events described in the narrative"; "The narrative affected me emotionally", 1 = *not at all*; 7 = *very much*).

Concept clarity. Seven items assessed the extent to which the participants felt that they had a clear concept of humanoid robots that assist the elderly. The items were introduced as follows "Service robots are human-like machines that will be widely used in (*blinded for review*) in a few years. A relevant field of use is the care for the elderly." Example items are "I could name several chores in which service robots could support elderly people" and "It is unclear to me how service robots can be used to support elderly people" (reverse coded). A five-point scale was provided (1 = *strongly disagree* to 5 = *strongly agree*). The reliability of the concept clarity scale was very good (α = .93).

Self-concept link. Seven items examined to what extent the participants felt that a service humanoid fitted their self-concept. Example items are "The use of service robots as support for elderly people is in line with my principles" and "I am reluctant to imagine service robots which support elderly people" (reverse coded). The items went with a five-point scale (1 = *strongly disagree* to 5 = *strongly agree*, α = .95).

Behavioral intentions. Our main dependent variable was a measure of behavioral intentions towards humanoid robots. Behavioral intentions were assessed with the help of seven items (e.g. "When I will be older and in need of care, I could imagine to use a service robot"; "If service robots were available for free, I would use this offer for my care-dependent relatives"). The items went with a 5-point rating scale (1= *strongly disagree* to

5= *strongly agree*, α = .91, see Table 1 for the relationships between the dependent measures).

< Table 1 around here>

Procedure and design

Each participant was randomly assigned to either watch *Robot and Frank* or *Safety Not Guaranteed.* After randomization, participants were accompanied to the room in which the full movie was screened. Each participant watched the movie together with other participants (group sizes varied from 5 to 18). After watching the movie, participants in both conditions worked on identical paper-and-pencil booklets that included our measures (transportation, concept clarity, self-concept-link, behavioral intentions). The final page entailed demographics and questions whether or not they had heard about or had seen the movie before.

Two weeks after the experimental session, participants received an e-mail with the link to an online survey. This survey included the concept-clarity scale, the self-concept-link items, and the behavioral intentions scale. The participants answered the online survey with an average delay of 16.17 days (*SD* = 3.03). After completing the online survey, the participants were thanked and fully debriefed.

Since two movies were used as treatment manipulation, the experiment followed a one-factorial between subjects design (treatment: movie condition). The supposed mediators (concept-clarity, self-concept link) as well as the dependent variable (behavioral intentions) were assessed immediately and with a two-week delay.

Results

In these and the following analyses, the experimental treatment was dummy-coded (control movie = 0; humanoid robot movie *Robot and Frank* = 1). We expected that the control movie yielded about the same narrative involvement as the experimental movie *Robot and Frank*. Participants' transportation ratings of the control movie ($M = 5.21$; $SD = 0.82$) and the *Robot and Frank* movie ($M = 5.18$; $SD = 0.88$) were almost identical, $t(54) = .11$, $p = .91$. Both movies were equally transportive. The results presented below remain virtually unchanged if transportation is included as a covariate and transportation did not moderate the paths of our model.

To examine the influence of watching a science fiction movie about a humanoid robot on recipients' meaning frameworks and behavioral intentions, two multi-mediator-analyses were conducted (Hayes, 2009; 2013; model 6). We first present an analysis for the data obtained immediately after watching one of the two movies (Figure 1a), and we repeat the analysis for the data obtained after the two-week delay (Figure 1b).

< Figure 1 around here >

The analysis for the immediate measures yielded a non-significant *total effect* of the movie on the DV behavioral intentions, $b = .16$, $SE = .25$, $t(53) = .62$, $p = .54$. Likewise, no *direct effect* of the movie treatment on the behavioral intention measure was found, $b = .03$, $SE = .18$, $t(51) = .18$, $p = .86$. However, the analysis yielded a significant effect of the movie condition on the concept clarity, $b = 1.00$, $SE = .23$, $t(53) = 4.37$, $p < .001$, reflecting higher clarity after watching the humanoid robot film. Concept clarity was in turn significantly associated with the self-concept-link, $b = .38$, $SE = .15$, $t(52) = 2.56$, $p < .05$, and those who could relate to the humanoid had more positive behavioral intentions

towards the robot, $b = .79$, $SE = .08$, $t(51) = 9.37$, $p < .001$. Importantly, the paths outlined above composed an indirect mediation effect. A bias-corrected bootstrap confidence interval (CI) for the indirect effect of movie treatment on behavioral intentions via concept clarity and self-concept-link based on 10000 bootstrap samples was significant *estimate* = .30 (95% CI: .07, .70).

A very similar pattern of results was found for the measures obtained after a two-week delay: The total effect of the movie on the DV behavioral intentions was non-significant, $b = .12$, $SE = .26$, $t(54) = .46$, $p = .65$[2] as was the direct effect of the movie treatment on the behavioral intention measure, $b = .02$, $SE = .16$, $t(52) = .10$, $p = .92$. We again found a significant effect of the movie condition on the concept clarity, $b = .97$, $SE = .23$, $t(54) = 4.22$, $p < .001$. Higher concept clarity was in turn related to a stronger self-concept link, $b = .39$, $SE = .14$, $t(53) = 2.71$, $p < .01$. Higher self-concept link scores were in turn related to more positive behavioral intentions towards the robot, $b = .85$, $SE = .08$, $t(52) = 10.98$, $p < .001$. The analysis also shows a significant indirect mediation effect, *estimate* = .32 (95% CI: .08, .76).

Taken together, our results reveal an indirect path between exposure to a science fiction movie featuring a humanoid robot and behavioral intentions to buy or use this future technology. We identified a mediating process consisting of a clearer understanding of the humanoid and a greater connection to the concept to the self. This pattern of results was basically unchanged after a two-week post-exposure delay, supporting the notion that fictional stories can have stable effects on recipients' meaning frameworks.

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[2] Degrees of freedom for t-values for t_2 are different from t_1, because one participant did not answer the behavioral intentions scale for t_1.

Discussion

The influence of fictional stories goes beyond entertainment. Stories affect how we feel, think, and act. With this work, we argue that one of the main functions of fictional stories is to provide meaning. We introduced meaning as the presence of expectable relationships of entities within the self, the outside world and between the self and the outside world (Heine et al., 2006). We identified humanoid service robots as a technological innovation that is expected to be part of our everyday life in a few years (International Federation of Robotics, 2014). Humanoid robots, however, likely elicit negative responses by consumers as meaning frameworks of established relationships are yet to be established (cf., Mori et al., 2012). Stories are a potent source of meaning due to the relationships between its elements, inherent to the format as well as the content patterns of conflict and resolution (e.g., Gottschall, 2012).

In our experiment, recipients of a full-length science fiction movie featuring a humanoid service robot had a clearer concept of humanoid service robots and they felt a closer connection of these robots to the self, which led to an indirect effect of movie exposure to behavioral intentions to use or purchase a humanoid service robot in the future. This result was observed immediately after watching the movie and after a two-week post-exposure delay, adding to the growing evidence on the rather stable influence of fictional stories (e.g., Appel & Richter, 2007; Jensen et al., 2011). At both points of measurement, there was a main effect of the humanoid robot movie on the clarity of the concept ‘humanoid robot’, but no total, overall effect of the treatment on recipients’ behavioral intentions. Interpreting this finding, we assume that understanding the concept of a new technology can not only provide the basis for a closer connection to the self – which

translates to higher willingness to purchase and engage in the technology. Rather, understanding the concept of a new technology can possibly trigger aversive responses that are due to a greater clarity about this technology. Future research needs to address this complex interplay in more detail. The indirect path was of key interest in this study. We cannot rule out that, given our sample size, the power to identify the indirect path was sufficient, whereas the power to identify the total effect might have been too small (cf., Kenny & Judd, 2014).

The present work contributes to current research in several regards. This work adds to our understanding of meaning in relation to stories (e.g., Bartsch, Kalch, & Oliver, 2014; Oliver et al., 2012; Oliver & Bartsch, 2009). We provided a clear definition of meaning, introducing meaning as the presence of expectable relationships between the things in the world, the self, and the self in the world (Heine et al., 2006). We assume that the characteristics of fictional stories facilitate the development of concepts and patterns about the outside world and how the self connects to it. Possibly, this fundamental function of stories underlies the widespread use of stories to explain and cope with meaning-threatening incidents humans are faced with, such as the death of loved ones and one's own mortality (e.g., Koopman, 2014; 2015; Rieger et al., 2015). Our focus was on the meaning generating function of science fiction in the field of technological innovations. Our findings indicate that other potential meaning threats could be alleviated by works of fiction.

Our results further suggest that the power of fiction is not limited to realistic, real-life content and incidents (cf., Rapp et al., 2014). Using an existing full-length feature movie we showed that even stories that remarkably diverge from today's reality can have real-world effects. This study contributes to our knowledge on the effects of science fiction,

which has attracted little empirical research so far. This is surprising, given a steady interest in this topic in various disciplines, including the natural sciences and the humanities (cf. Bailenson et al., 2007). Early science fiction pioneers, like Hugo Gernsback, had hoped that science fiction might be a tool to introduce novel technologies to wide audiences (Crouch, 1982). The current research indicates that science fiction might indeed provide meaning for individuals who are faced with new science and technology.

Our study further adds to the field of human-robot interaction, which will become increasingly relevant, given that robots will be part of the daily environment of industrialized societies in only a few years (e.g., Newenham, 2014; Wakefield, 2014). From a social science perspective, users' experiences and interactions are not only shaped by a robots' visual appearance and functionalities, but cognitive representations of robots obtained prior to the first interaction are of key importance as well. Indeed, our first encounter with new technologies typically takes place in mediated worlds – many of those worlds are worlds of science fiction.

Limitations and outlook

The following limitations need to be noted: First, our aim was to use a straightforward operationalization of the defining components of meaning based on the meaning maintenance model (Heine et al., 2006). We relied on a self-report measurement, assuming that the presence or absence of meaningful relationships underlying a concept (concept clarity) and the relationship between the self and this concept can be reported by our informants. Possibly, all or parts of these processes can also be tracked more indirectly, for example with implicit association measures (e.g., Gawronski & De Houwer, 2012; Greenwald et al., 2002). Studies on the influence of stories (Dal Cin, Gibson, Zanna,

Shumate, & Fong, 2007; Gabriel & Young, 2011) as well as research on attitudes towards robots (MacDorman, Vasudevan, & Ho, 2008; Mitchell, Ho, Patel, & MacDorman, 2011) speak to the feasibility of this approach. Future studies are encouraged to follow this research avenue.

Second, our sample consisted of undergraduate students. For individuals in their early twenties, elderly care is likely a topic of low to moderate personal relevance and undergraduates are arguably less knowledgeable in the field of elderly care than older participants. For individuals with higher personal relevance and knowledge about a technological innovation the influence of science fiction on concept clarity might be reduced, as meaning frameworks could already be established. However, if a functional meaning framework in a given domain of high relevance is lacking, stimuli that help establishing meaning could have an even greater impact on concept clarity, the self-concept link and behavior intentions (cf., Heine et al., 2006). Examining the moderating effects of personal relevance and knowledge is an important avenue for future studies.

Third, we used a full-length feature film, *Robot and Frank* (Schreier, 2012), as our stimulus (vs. control film) to heighten the study's external validity. We cannot rule out the interpretation that the findings might have been different for a different movie. Particularly fictional stories in which new technologies are introduced as a dangerous result of human hubris might yield more negative results. According to our theoretical framework, however, any neutral or positive depiction of future technologies should increase the meaning associated with the new (robotic) technology and therefore yield higher acceptance. We chose to compare the science fiction movie with a control film that was similar in several respects but did not address robotic technologies at all. Another feasible strategy (cf., Mara

& Appel, 2015) would be to construct a non-narrative movie (e.g., a documentary) with similar information on the topic. Despite the substantial challenges associated with this approach (e.g., reducing the internal and external validity by developing artificial stimuli) future research in this direction is encouraged in order to examine the role of narrativity more closely.

Fourth, we tested our assumptions with respect to humanoid robots, but the meaning-generating function of science fiction likely applies to other fields of innovation as well. The TV series *Star Trek* (Roddenberry, 1966), for example, might have already provided meaning frameworks for teleportation and replication[3] – a technology that might have facilitated the acceptance of current 3D-printing applications. Likewise, science fiction – or fiction more generally – can and will affect how non-experts think and feel about new, innovative (and scary) technologies, for example in the energy or life sciences sectors. From a science communication perspective (cf. Dahlstrom, 2014), science fiction could be a potentially very powerful means of communication and influence.

Conclusion

How can *extravagant fiction today* become *cold fact tomorrow*? (cf., Amazing Stories, 1926). Our experimental evidence indicates that science fiction provides a clearer understanding of future technologies, which in turn facilitates the perceived connection between the technology and one's own life, resulting in a greater acceptance of this technology.

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[3] The "food synthesizer" in the original *Star Trek* series and the "replicator" in *Star Trek: The Next Generation* were machines capable of creating objects on demand.

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Table 1

Zero order correlations between the observed variables at Time 1 (above the diagonal), and at Time 2 (below the diagonal).

	M_{t1} (*SD*)	M_{t2} (*SD*)	Concept clarity	Self-concept link	Behavioral intention
Concept clarity	3.18 (.94)	3.38 (.88)	-	.31*	.33*
Self-concept link	2.35 (1.04)	2.57 (1.02)	.30*	-	.82**
Behavioral intention	2.62 (.93)	2.80 (.94)	.36**	.86**	-

Notes. *N*s ranged from 55 to 56 due to occasional missing data. * $p < .05$, ** $p < .01$

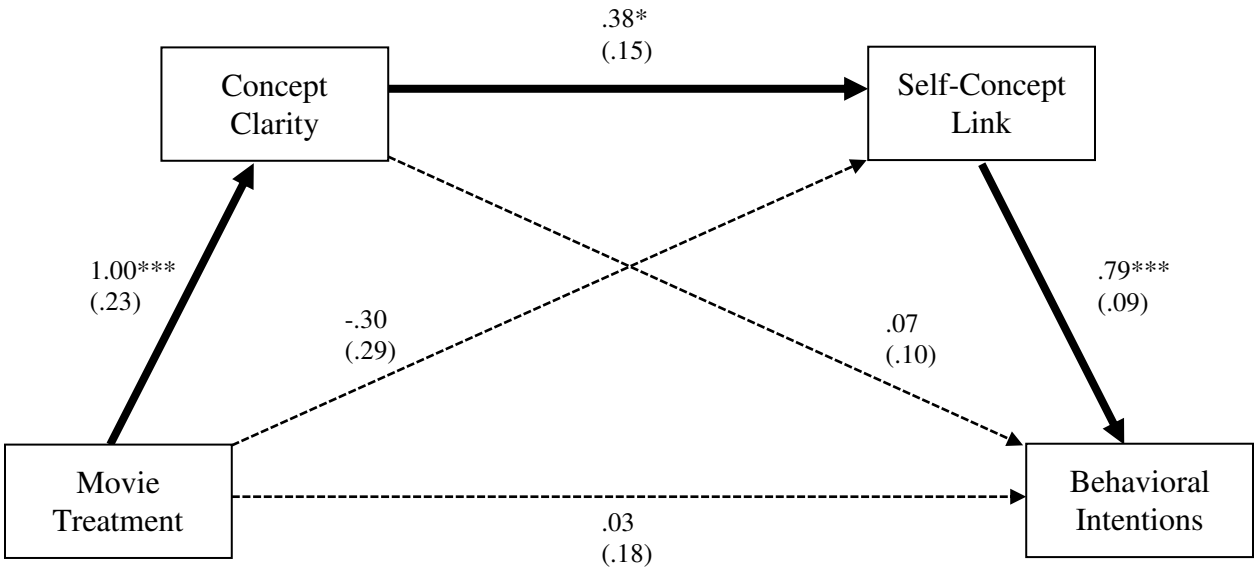

Figure 1a. Two-step mediation model for the variables assessed immediately after exposure (Hayes, 2009; 2013, model 6) * $p < .05$, ** $p < .01$, ** $p < .001$

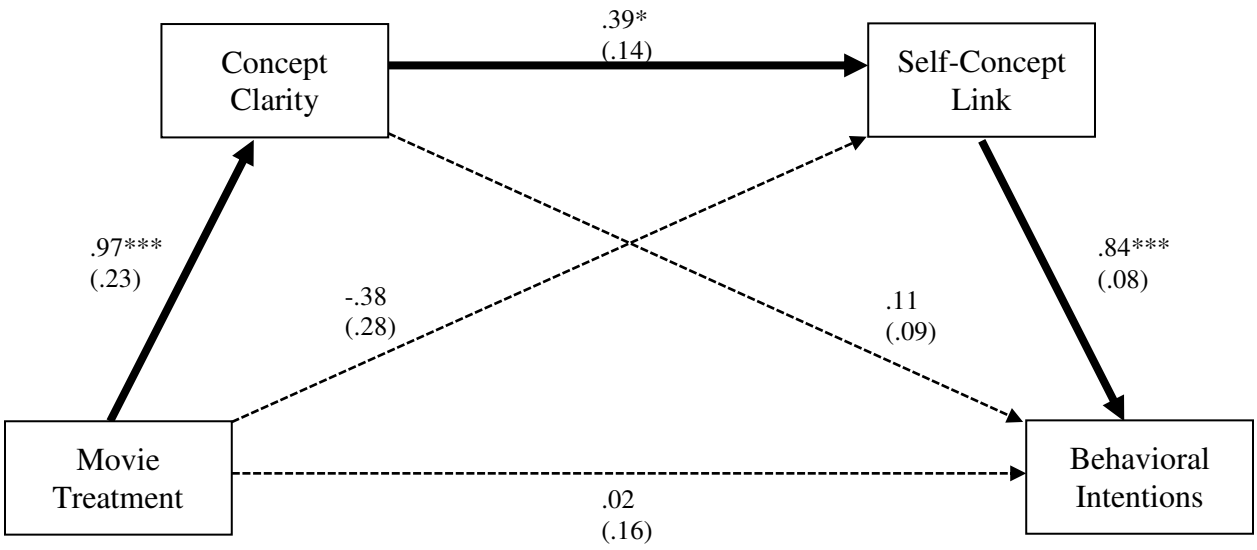

Figure 1b. Two-step mediation model for the variables assessed with a two-week delay (Hayes, 2009; 2013, model 6) * $p < .05$, ** $p < .01$, *** $p < .001$