Should We Use an Abstract Comic Form to Persuade?

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ABSTRACT

This paper examines if messages when expressed in abstract comic form are more persuasive. In collective action dilemmas such as public health, or for people who track their daily routines, information about their behavior plays an important role in decision making. Whether comic representations, despite widespread use in popular culture, offer any tangible benefits over plain text messages in persuasion is unclear and motivates our study. Drawing on a rich history of the comics (the importance of abstraction) and theories from behavioral economics (information framing) and psychology (social proof), we synthesize persuasive messages in an abstract comic form. We conduct two field studies: the preference of abstract comic form to text; the use of comic form to persuade in a charitable donation scenario. Motivated by its use in small sized studies, we use a hierarchical Bayesian model to analyze the results. Our experiments reveal that: abstract comic representation is preferred to text (moderate effect size=0.32); abstract comic form is more persuasive than text (medium effect size=0.48). Information framing and social proof improve comic effectiveness, but the effect is minor. Our studies have design implications: we ought to consider the abstract comic form to communicate messages intended for behavior change.

KEYWORDS

statistical facts, abstract comics, persuasion, information framing, social proof, hierarchical bayesian models

1 INTRODUCTION

Are text messages (e.g. "you've exercised 25% more than you did last week") more persuasive when expressed in comic[1] form? Embellishing a text message using a comic form appears to be a "Supposedly Irrelevant Factor" [30], that ought to make no difference to a decision maker since the comic offers no additional information.

The notion of behavior change motivates us to address this question. As the quantified self movement [7, 3] illustrates, people have an enduring sense of curiosity about their lives, and develop different processes to instrument (e.g. using a wearable device) and to reflect on data gathered about their activities. Individuals use this information ("checked in at the gym twice this week"), to take decisions to change behavior (e.g. "exercise more"; "eat healthy"). While visualizations often accompany these messages (e.g. a graph of weight over time for a person interested in weight loss), the message itself is presented in textual form.

Human beings show significant resistance to changing their behavior. While there may be confounds that explain away poor adoption, including, message timing [8] (i.e. when we show the fact), time scarcity [13] (i.e. we don't have time to digest the information), viewing messages on smartphones [15] (screen is too small to communicate effective visualizations), rethinking the textual form of the message for easier consumption in the context of behavior change has been largely unexplored.

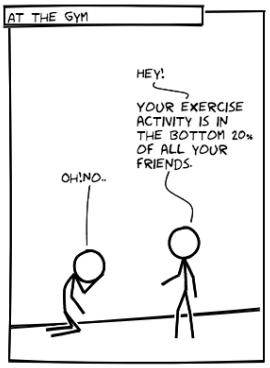

Figure 1: The figure highlights information framing and the use of an abstract comic form.

Three ideas underpin this paper: information framing, "social proof," and the comic form. First, work in Behavioral Economics [31, 32] shows that how we frame the text matters and can cause preference reversal. Briefly, individuals show different preferences to statements with identical information due to risk aversion. Second, work in Psychology shows that individuals' decisions are guided by social norms [10, 28]. Finally, we use comics in abstract form to communicate. Comics is a sophisticated form of art [21] that popular across cultures allowing for use of humor and affect in communication. We focus on abstract comic representations (see Figure 1). By an abstract representation, we mean that the comic de-emphasizes character detail (face, eyes etc.), or details about the locale. As McCloud [21] points out, using abstract representations for the comic allows the reader to project themselves onto the comic character. Equally importantly, if we wish to algorithmically synthesize comic-style messages, abstract representations allows for a straightforward synthesis and for use in a wide variety of contexts. While the comic form has found use in scientific communication [22] and in a multilingual classroom [1], its use in behavior change is not yet well understood.

[1]We use "comic form" as opposed to the more formal "graphic form" to avoid any confusion with other visual representations of data, including charts and diagrams.

Submitted to CHI, 2019, Glasgow, UK.
2018. ACM ISBN 978-x-xxxx-xxxx-x/YY/MM…$15.00

To examine the question if the abstract comic form is more persuasive than the corresponding text message, we employed an iterative design framework and conducted two studies (after IRB approval) on Amazon Mechanical Turk. In the first study (n = 146) we examined if the comic form is preferred over text. We manipulated character gesture (3 cases), distance between characters (3 cases), shading (3 cases) and framing (2 cases), giving us a total of 54 conditions. In the second study on persuasion (n = 307), we examined if participants are persuaded to donate to a charity when presented with a three panel comic; we also performed an additional experiment that combined the idea of the social proof with the comic message.

We analyzed the results of both studies using a hierarchical Bayesian framework. Consistent with the observations by Kay et al. [14], we believe that beyond the role of Bayesian analysis on the issue of replicability, by shifting the question from the binary "did it have an effect?" to "how strong is the effect?" is important in small-n studies common to HCI.

Our contributions are as follows:

Preference study: We show through our first study that the comic form is preferred over the text message. The effect size (0.32) is moderate, but significant. Our further analysis shows that while information framing improves the preference of the comic, the effect is minor and not significant. Similarly, gesture, inter-character distance, and shading all have minor, not significant effects.

Persuasion study: We show through our second study that the abstract comic form is more persuasive that the corresponding text message. The effect (0.48) is of medium size and significant. The use of the social proof improves the persuasiveness of the comic, but the effect size is minor (0.12) and not meaningful.

Our findings have several design implications. First, we could consider using an abstract comic form to communicate messages for behavior change (e.g. wearable devices). Second, abstract comic form messages can be algorithmically synthesized, by mapping the frame type (positive or negative) to the character gesture, and the statistical information may be obtained from a person's history and from behavioral data of friends who have agreed to share.

We organize the rest of this paper as follows: we first discuss related work and motivating ideas. Then, we present our first study on preference followed by our second study on persuasion. Then, we discuss the implications of our results, including study limitations, followed by conclusions.

2 RELATED WORK

Now, we discuss related work in: 1) building persuasive technology and 2) persuasion through visual stimuli.

Building Persuasive Technology

Starting from Goehlert [9], HCI researchers have spent a lot of effort in leveraging technology in persuasion. Goehlert [9] argues control and dissemination of information have the ability to make attitude and behavioral changes. Inspired by this argument, two approaches have been explored in constructing the persuasive systems. Information-centric approaches focused on delivering hidden or new information which has not been perceived by the user before [19]. For example, Chi et al. [2] changed people's nutritional composition by creating an intelligent kitchen that can provide nutritional information about ingredients while participants are cooking. Liao et al. [20] found showing a source expertise indicator can shape user's information seeking and burst the filter bubble. While lots of studies on persuasive technology showcase the persuasive power of the information-centric approach, studies also show the downside of information-center approach where the target receiver often failed to perceive and internalize the persuasive information [9, 19].

Adapting decision-making models from previous behavioral research, behavior-centric approach emphasized on human motivation and biases [19]. Vaish et al. [33] used self-serving motivational framing of messages to persuade people to join a prosocial peer-to-peer service. Although the effectiveness of behavior-centric approach has been examined in multiple studies, behavior-centric approaches often require prior knowledge of the persuadee in order to unleash the persuasion power, as Orji et al. [24] and Schneider et al. [27] suggested that different people may be more amenable to one persuasive method than others. Therefore, due to the cost of knowing people, scalability is the key challenge.

Persuasion Through Visual Stimuli

Prior research shows that using visual representations are more attractive than text messages [29, 6]. Selker et al. [29] retrieves motivational images from 9GAG, Google, with energy-saving messages, to motivate people's energy saving behaviors and found those images has higher persuasive power comparing to plain text. However, images used in persuasion are costly to generate.

The simple and humorous nature of comic makes comics becomes an unique media for delivering informative and memorable messages. Beyond entertainment, comics can be used in scientific communication [22], and for teaching in multilingual schools [1]. To the best of our knowledge, this is the first study to look at abstract comic representations and persuasion.

3 MOTIVATING IDEAS

In this section, we present three key motivating ideas: social proof, information framing and abstract comics.

Social Proof and Framing

Two ideas "social proof" (from Psychology) and "information framing" (from Behavioral Economics) are central to our study. By "social proof," we refer to the idea that individuals observing either their friends, or people with whom they can relate adopt a behavior, is persuasive for them to adopt the same behavior [4, 5]. The use of "social proof" has been experimentally demonstrated in environmental conservation [10] and in energy conservation [28]. Information framing refers to the idea that presenting outcomes as a gain or a loss, alters decisions [32, 31], since individuals are loss-averse and weigh losses more severely than similar gains.

The Abstract Comic

McCloud [21] defines comics as "juxtaposed pictorial and other images in deliberate sequence, intended to convey information and/or to produce an aesthetic response in the viewer." The simplicity of the comic form allows for delivering memorable messages [21]. In this study, we are motivated by the use of abstract comic form. McCloud [21] points out that the reader is more likely to project themselves onto the character in the comic when the comic is more abstract. By taking the perspective of the character, the reader will internalize the information their character is trying to express or receive. If the information is persuasive, the internalization will imply a higher chance of target behavior change. Figure 2 shows an example.

McCloud [21] identifies several fundamental components that influence reader reaction: character gestures, inter-character distance, and shading intensity. For example, the gesture of a character can help reader to understand interaction between characters and the emotion of the character. As a common technique, cartoonists often use the gesture to intensify the feeling that they want to communicate to the reader [21]. We plan to incorporate three variations of each of these elements in our first study.

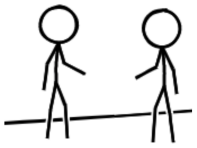

Figure 2: An abstract comic example.

4 STUDY ON PREFERENCE: METHOD

In this section, we discuss our methodology for evaluating the preference of the message shown in the abstract comic form over the plain text message. First we discuss the messages used with positive and negative framing. Then, we show how to synthesize the abstract comic messages. Then we discuss our HIT design on the Mechanical Turk.

Composing Persuasive Messages in Plain Text

We use simple text messages with a goal to persuade subjects to engage more physical activity. We chose this topic as the health is a topic to which our study participants could relate. We kept a single topic to avoid any any experimental confounds due to different topics.

We constructed messages based on the idea of social proof [10], where the messages emphasized the relationship between the subject and her group of friends. We created two sets of messages that either framed from a positive standpoint or a negative standpoint [32].

We used the following positive and negatively framed messages in our study. *Positive framed persuasive messages:*

(1) In the past week, you spent more time at the gym than did 65% of your friends
(2) Congrats! You have reached your goal of exercising three times a week.
(3) Over the past month, you exercised more than did 90% of your friends.
(4) Your exercise activity is in the top 20% of all your friends.
(5) Over the past three weeks, you went to the gym more often than 60% of your friends did.

Negative framed persuasive messages:

(1) In the past week, you spent less time at the gym than did 65% of your friends
(2) Oh! You did not reach your goal of exercising three times a week.
(3) Over the past month, you exercised less than did 90% of your friends.
(4) Your exercise activity is in the bottom 20% of all your friends.
(5) Over the past three weeks, you went to the gym less often than 60% of your friends did.

Generating Comics

In this study, we adapted an open source comic generator [12] to generate abstract comic messages. The generator impersonates the style found on 'XKCD' [23] comic. Our focus is not the XKCD style, but the fact that the comic form generated by [12] is abstract. The message we generate includes two characters in a conversation and the scenario is 'One day, your friend has something to tell you.'

To make a fair comparison between plain text representation and the comic form, the content of text bubble is the same in both conditions. We discuss generation of elements of gesture, distance between characters and shading below.

Gesture : We created the gesture library with two main categories: positive and negative corresponding to how the original message is framed, each with three levels of emotional intensity see Figure 3.

(a) Gestures for positive framed messages **(b) Gesture for negative framed messages**

Figure 3: Different character gestures to communicate various levels of emotional intensity. The left figure shows gestures used in positive framed messages from neutral to the happiest. The right figure shows gesture used in negative framed messages from neutral to the most frustrated.

Inter-character distance : For the distance between two characters, we have three levels of variance from close to medium separation to large separation. The three levels of distance represents the relationship between to characters as close friends, friends, and acquaintances.

Shading : For the background shading, we have three-levels , white, grey, and dark grey. Each color represents a level of emotional intensity correspondingly, white as [21].

In total, for each message we have a total of $3 \times 3 \times 3 \times 2 = 54$ variations in terms of character gesture, inter-character, background shading, and message framing. In this study, we created 270 comic form messages corresponding to 5 plain text messages.

Since the prior work [10, 28] suggests a robust effect of the social proof, instead of using it as part of an experimental condition, we will have two characters in the comic, shown as friends or the experimenter, whose inter-character distance we manipulate. Second, we will incorporate framing in the text bubbles accompanying the comic.

Study Design

To answer our research questions, we designed and after IRB approval, conducted a between-subject online study on Amazon Mechanical Turk.

Experiment Procedure. Once participant consented to join our study, they were randomly assigned to two conditions 1) Positive message condition where all persuasive messages are framed in a positive way and 2) Negative condition where all persuasive messages are framed in a negative way. In both conditions, participants will see a total of five persuasive messages in both plain-text representation and comic representation shown side by side. Then, the participant rates which representation of the message is perceived as more persuasive on a 7-item Likert scale.

Display Order. To mitigate any potential bias toward the display order of the plain-text representation and comic representation we randomize the display order. Both plain-text representation and comic-style representation have equal chance to show on the left side.

Attention Checker. To control the data quality, we embedded two attention checkers in the study. The first one appears after the third comparison and the second one shows up after the last comparison. Both attention checkers asked subjects to choose a comic that matches a simple description, e.g. "Which of the following comics has two characters?"

Rating Scale Design. The 7-item Likert scale ranges from -3 (left) to 3 (right) where 0 means neutral. The direction of the scale flips corresponding to the position of the comic and plain text.

A Pilot Study. Before the experiment, we first conducted a pilot study with 10 participants and collect their opinions about the study process and design. Based on the feedback from our pilot test, we iterated our study design. In the final design, we fixed the order of the rating scale. However, since the order is fixed, potential demand characteristics may be introduced by the scale direction [25]. To minimize potential bias we added another layer of randomness in our final design. The direction of the scale no longer changes respect to the position of the messages within subjects, but the direction of the scale is randomly assigned between subjects. Also, we replaced the numbers on the scale by text as neutral, slightly persuasive, text/comics is more persuasive and strongly persuasive. Finally, we adjusted the size of the comic and text to make sure both of them have similar readability.

Participants. We published our HITs on the Amazon Mechanical Turk titled with "A short survey about your exercise motivation." The price tag for each HIT was $8/hr, and the workers would get these rewards regardless of their performance. The threshold for participant to join our study was a 95% Approval Rate. On the HIT page, participants would see a link to our experiment site. Workers who repeat the task will be rejected as we instructed in the task description.

5 STUDY ON PREFERENCE: RESULTS

In this section, we will first present the raw data used in the analysis, then introduce the Bayesian Model we used for data analysis and our analysis result.

Raw Data

In total we have 146 participants joined our study, 73 of them in negative framed condition and 73 of them in positive framed condition. 5 participants are removed due to incomplete data. 4 participants are removed due to failed at least one attention check question. 6 participants are removed due to multiple attempts. The following analysis is

based on a dataset with 131 participants (655 observations), 63 of them is in positive framed condition and 68 of them is in negative framed condition.

Bayesian Model

We use a Bayesian formulation of the problem of identifying suitable predictors for the messages in comic form. Kay et al. [14] provide an nice introduction on the appropriateness of Bayesian analysis for the HCI community. Bayesian analysis is attractive in our experiment due to two advantages: shifting the conversation from "did it work" to "how strong is the effect"; and benefits to small n studies.

Bayesian inference can sometimes differ from say a standard t-test widely used to compare two groups in the standard Null Hypothesis Significance Testing (NHST) framework. This is because the t-test assumes that the two populations from which samples are drawn, follow a Normal distribution, an assumption that can be violated in practice. Non-Normality is easily accounted for in a Bayesian formulation and Kruschke [17, p. 470] points out that the Normality assumption is one explanation why a t-test may be less sensitive to differences than a Bayesian analysis.

We manipulate four independent variables: gesture of the participants in the comic (3: neutral, moderate, extreme); distance between the two characters (3:close, moderate, far); comic shading (3:white, light gray, gray); framing (2: whether the information was positively framed or negatively framed). This gives us a total of $3 \times 3 \times 3 \times 2 = 54$ experimental conditions. As a control against ordering effects, we randomly manipulate comic position (whether we presented the comic panel to the left or to the right). Thus, we need to estimate the effect on the responses for each of these variables; the responses are on a 7 point Licket scale.

A challenge with using ordinal scale such as the Lickert scale: we do not know the "width" of each response. That is, while we may know that for example $1 < 2 < 3$, we don't know if the difference in the thresholds used by subjects to mark "2" on the scale, is the same as the difference in thresholds they use for "1" and "3." We assume that each response by a subject: lies in a continuous metric space; is Normally distributed; and that the thresholds $\{\theta_i\}$ while unknown, are shared—all subjects use same set of thresholds to identify the appropriate ordinal value.

Formally let z be the observed ordinal response of the subjects. The subjects respond to a comparison between a message in text, and the same message in comic form. We generate the comic panel based on the experimental condition; the setting of each of the k independent variables $\{x_j\}, j \in [1 \ldots k]$ determines the condition. The subjects first generate a Normally distributed metric variable y, and then use the thresholds $\{\theta_i\}$ to map y to the ordinal variable z.

Then, since we assume that the metric variable y is Normally distributed, our hierarchical Bayesian model is defined as follows:

$$y \sim N(\mu, \sigma_y) \tag{1}$$

$$\sigma_y \sim U(L, H), \tag{2}$$

$$\mu \sim \beta_0 + \underbrace{\sum_j \beta_{1,j} x_{1,j}(i)}_{\text{gesture}} + \underbrace{\sum_k \beta_{2,k} x_{1,k}(i)}_{\text{shading}} + \underbrace{\sum_l \beta_{3,l} x_{1,l}(i)}_{\text{distance}} + \underbrace{\sum_m \beta_{4,m} x_{1,m}(i)}_{\text{framing}}, \tag{3}$$

$$\sum_j \beta_{i,j} = 0, \qquad i \in \{1, \ldots, 4\}, \tag{4}$$

$$\beta_{i,j} \sim N(0, \sigma_{\beta,i}), \qquad i \in \{1, \ldots, 4\}, \tag{5}$$

$$\sigma_{\beta,i} \sim \Gamma(s, r). \tag{6}$$

Equation (1) says that the metric variable y is Normally distributed[2] with mean μ and standard deviation σ_y. Equation (2) says that the standard deviation σ_y of the response y is drawn from a Uniform distribution with constant parameters Low $= L$, High $= H$, where $L > 0, H \gg L$. Equation (3) says that the mean response μ is a linear weighted combination of the predictors. Equation (5) says that the predictor weight is drawn from a zero-mean Normal distribution with standard deviation $\sigma_{\beta,i}$. That is, while *each* predictor set β_i is drawn from a *different* Normal distribution, the $\beta_{i,j}$ values within the same predictor set β_i are drawn from the *same* Normal distribution. Equation (4) says that the sum of the deflections $\sum_k \beta_{j,k}$ from the mean for any nominal predictor j equals zero.

Equation (6) says that we draw all the variances $\sigma_{\beta,i}$ from a Gamma $\Gamma(s, r)$ distribution, where s refers to the shape parameter and r refers to the rate parameter. We set the variables s, r to allows a wide range of values for $\sigma_{\beta,i}$. Notice that we draw the variances $\sigma_{\beta,i}$ of each predictor i from an independent Gamma distribution, implying that the variances (equivalently, the extent of deflections from the mean) for each predictor can be different. The main advantage of using a Gamma distribution is that we can specify a non-zero mode, important in controlling shrinkage in hierarchical models. By drawing the standard deviation variables $\sigma_{\beta,i}$ from a Gamma distribution, the values of each element of β_i informs the other elements. The "information sharing" among variables common to hierarchical Bayesian

[2]The "~" symbol means that the random variable on the left is drawn from the probability distribution on the right.

models and is an important reason why Bayesian models work so well with small datasets[3].

Thus far, we have discussed how to generate a Normally distributed metric variable y. However, what we see in the experiment is not this metric variable, but an ordinal variable r. The subjects use internal thresholds $\{\theta_i\}$ to determine when to "strongly disagree", "disagree" etc. Thus with a 7 point Likert scale, we have 6 thresholds. The probability that we will see an ordinal response $r = k$ is $P(r = k|\mu, \sigma, \{\theta_i\})$, where, $\{\theta_i\}$ is the set of thresholds used by the subjects. We assume that while these thresholds are unknown, all subjects use the same thresholds. Since the underlying metric response y is Normally distributed, we can compute the probabilities for observing each ordinal response $r = k$ as follows:

$$P(r = k|\mu, \sigma, \{\theta_i\}) = \Phi\left(\frac{\theta_k - \mu}{\sigma}\right) - \Phi\left(\frac{\theta_{k-1} - \mu}{\sigma}\right). \quad (7)$$

Where, Φ represents the cumulative density function for the Normal distribution corresponding to the underlying metric variable y. In other words, the probability that we will see ordinal response k is the area under the Normal distribution with parameters μ, σ between thresholds θ_{k-1} and θ_k.

The thresholds $\theta_i, i \in \{2, 3, 4, 5\}$ have two degrees of freedom in that a simple translation of the response will translate the thresholds. Consistent with Kruschke [16, p. 674], we set $\theta_1 \equiv 1.5$ and $\theta_6 \equiv 6.5$, leaving us with four hidden threshold parameters. We draw these remaining four $\{\theta_i\}$ from a Normal distribution as follows:

$$\theta_i \sim N(i + 0.5, 1/2), i \in \{2, 3, 4, 5\}. \quad (8)$$

In this section, we developed a hierarchical Bayesian formulation to model the subject ordinal response to analyze the effect of different predictors for three comic elements (gesture, distance, shading) and information framing. We have a total of 54 experimental conditions. We also modeled the thresholds for the different ordinal outcomes as a hidden variable. In the next section, we present and analyze the results.

Analysis

We analyzed the data using PyMC3 [26], a popular framework for Bayesian inference. Computational techniques for Bayesian inference use a stochastic sampling technique called Markov Chain Monte Carlo (MCMC) that samples the posterior distribution $P(\theta|D)$, where we want to estimate the parameters θ given the observations D. In particular, we used the Metropolis-Hastings sampler. The Gelman-Rubin statistic $\hat{R}$ was around 1, indicating that the different sampling chains converged. The modal values of the coefficients are shown in Table 1:

Table 1: Modal coefficient values β_{0-4}. Some coefficients are vectors as they represent the displacement from the mean for different conditions of that variable: Gesture (neutral, medium extreme); Shading (neutral, light gray, gray); Distance (closest, medium, farthest); Framing (negative, positive). For example, since gesture has three experimental conditions , β_1 is a vector of length 3.

Coefficient	Values
Intercept (β_0)	4.524
Gesture: (β_1)	$[-0.218, 0.101, 0.118]$
Shading: (β_2)	$[-0.218, 0.101, 0.118]$
Distance: (β_3)	$[-0.043, -0.057, 0.099]$
Framing: (β_4)	$[0.051, -0.051]$
Standard Deviation: (σ_y)	1.614

Our analysis shows that there is a preference of the abstract comic form over the corresponding text message. Figure 4 shows the mean effect and the effect size, as well as the contrast between positive and negative messages. The mean effect has a mode at $\mu = 4.54$ with the High Posterior Density (HPD[4]) interval of $[4.34, 4.71]$. Since the HPD lies outside a meaningful ROPE (Region of Practical Equivalence)[5] of 4 ± 0.25, the result implies that there is a clear effect due to the treatment. Furthermore, the figure shows a moderate effect size of 0.32; we consider an effect of 0.2 to be small, and an effect of 0.5 is a medium sized effect. Since the distribution excludes the ROPE interval $[0 \pm 0.1]$, the discovered effect size is meaningful.

Now, we summarize our remaining findings (we are omitting figures to conserve space) for this study for the thresholds θ and the four independent variables—framing, gesture, shading and distance. The posterior distributions of the thresholds $\{\theta_i, i \in \{2, 3, 4\}\}$ reveals that the HPD regions are outside corresponding ROPE intervals $2.5 \pm 0.1, 3.5 \pm$

[3]The sharing of information causes the variance of each individual element $\beta_{i,j}$ to move towards the group variance, a phenomena known as "shrinkage."

[4]The HPD interval is the location of 95% of the posterior density. This is similar to, but different from the idea of confidence interval used in classical statistics. See Hoekstra et al. [11] for a discussion on the misinterpretation of confidence intervals.

[5]Unlike classical statistics, where one can ask for example, if the two means for two treatments are different $P(\mu_1 \neq \mu_2)$, in Bayesian statistics, one asks if the HPD interval of the distribution $P(\mu_1 - \mu_2)$, the difference of the means of the two treatments, excludes an interval where we can consider the two treatments equivalent. This equivalence interval is domain dependent. In the Lickert scale, one could argue that $[4 \pm 0.25]$, is a meaningful ROPE for the mean effect, since the neutral effect case is $\mu = 4$, although smaller ROPEs of $[4 \pm 0.1]$ are also used.

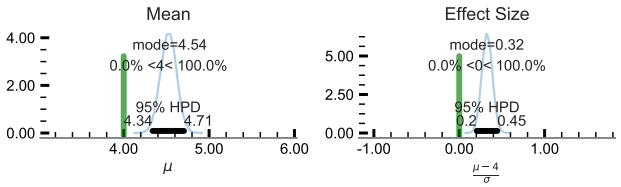

Figure 4: The High Posterior Density (HPD) intervals for the mean response μ and effect sizes σ_y. HPD represent the region with 95% of the density. Notice that the HPD interval for μ is $[4.34, 4.71]$ and excludes a ROPE of $[4 \pm 0.25]$ (the interval includes 4, the neutral response value). The figure for effect size shows a moderate effect with mode 0.32; since the HPD interval $[0.20, 0.45]$ excludes a ROPE of $[0 \pm 0.1]$, we can be confident about the discovered effect.

$0.1, 5.5 \pm 0.1$, implying that the discovered thresholds are meaningful.

Our analysis further shows that while types of framing, gesture, shading and distance all have an effect, these discovered effects are not convincing. A negatively framed message seems to have more of an effect that a positive message, but since the distribution that compares the outcomes of two message types includes a ROPE of 0 ± 0.1, the effect in this study is not convincing. While there is no meaningful difference between the gestures (all posteriors include a rope of $[0 \pm 0.1]$) a change from the neutral gesture has strong effect (more than 96% of the posterior excludes 0), but that extreme and medium gesture show almost no difference. A change from a neutral white background produces a strong effect (more than 97% of the posterior excludes 0), but there is no discernible difference between light gray and gray background color. While there is no meaningful difference between the distance conditions (all posteriors include a rope of $[0 \pm 0.1]$), a change to the farthest distance between the comic characters produces a moderate effect (more than 83% of the posterior excludes 0).

In this section, we presented a hierarchical Bayesian model to analyze the overall effect of using a comic to persuade, and understand the effect of three comic elements (gesture, shading and distance) and that of information framing. The use of comic produces a meaningful effect ($\mu = 4.54$), with an modal effect size of 0.32. Moving away from neutral gestures, neutral shadings produces a strong effect; the using large distance between comic characters produces a moderate effect. To further understand the persuasive power of messages in the abstract comic form, we conducted the second study to see how people make their charitable donation on real money after reading the comic message.

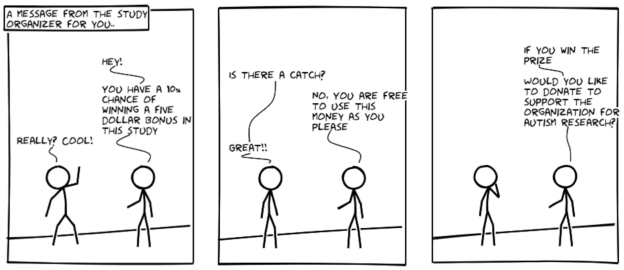

Figure 5: Messages in the abstract comic form

6 STUDY ON PERSUASION: METHOD

In this second study on Amazon Mechanical Turk, we examine if the abstract comic can impact a decision with monetary consequence. In contrast, the first study demonstrated that participants prefer messages in abstract comic form over text, but did not demonstrate persuasiveness. In this section, we will introduce the experiment design and describe our study participants recruiting process.

Experiment Design

Since the main goal for this study is to compare power of a persuasive message on behaviors in two forms, the abstract comic and the pure text, we first constructed two experimental conditions, abstract-comic (see Figure 5) and pure-text. In the abstract-comic condition, participants will read a message asking if they are willing to support a charity in a three-panel abstract comic strip, whereas in the pure-text condition, participants will receive the same message in pure text form. In addition, since the first study only indirectly tested social proof by altering the inter-character distance, in this study, we develop a three-panel comic that includes the normative behavior (see Figure 6).

The objectives of the persuasive message in all three conditions: persuading participants to donate to a charity using a prospective bonus reward (10% chance of winning $5 bonus). We randomly assigned study participants to one of the three conditions; the participants are free to make a decision on the amount of donation, including not donating at all.

Study Procedure. Once a participant consents to join the study, we ask them if they are familiar with the Autism Spectrum Disorder (ASD). Then, each participant watches a short-video produced by the Organization for Autism Research that promotes its fundraising activity "RUN FOR AUTISM". After watching the video, we ask participants to summarize the video using free text and ask them to provide their opinion about the effectiveness of the video. The recruiting message specifically mentions this task of soliciting their opinion on the message effectiveness.

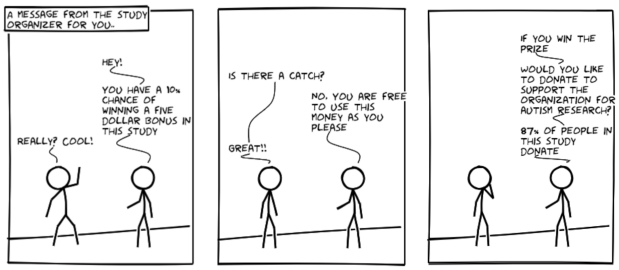

Figure 6: Messages with social proof.

We randomly assign participants to each of the three conditions and and then ask them to read the corresponding persuasive message (text, three-panel comic, three-panel comic with social proof). In the message, we provide the participant with a 10% chance of winning $5 additional compensation. We also provide them with the opportunity to donate to the Organization for Autism Research (OAR) which is the charity mentioned in the video they watch as part of the study.

To best demonstrate the persuasiveness of the message itself, we diffused the responsibility of donation amount among all participants. Consistent with Lee et al. [18], before the participants make their decision, they read "The total amount of money allocated to [the charity] by all the winning participants will be aggregated and donated at the end of the study." Then, we ask the participants to decide the amount of money they are willing to donate on a slider bar with $0 and $5 as two extreme ends. The default position of the slider bar is at the $0 end.

Before leaving the study, the participants we ask the participants to fill a demographic questionnaire about their gender, age and education; the participants have the option of declining to state an answer for each question.

At the end of the study, we randomly chose 10% of the participants, donated to OAR based on the participants decision, and rewarded each chosen participant the part of the bonus that they wished to keep.

To gather the basic statistics to create social proof, we first ran a pilot study with the first two conditions ($n = 60$) and used the donation statistics as part of the social proof message. In the pilot study, 87% of the participants donated a non-zero amount.

Organization for Autism Research (OAR). To increase the realism of our study, the donation decision is not hypothetical and participants are rewarded based on their decision and we as study organizers donate to the Organization for Autism Research (OAR). We chose OAR as the charity in our study for three reasons. First, Autism Spectrum Disorder (ASD), is a well-known, serious developmental disorder that impairs the communication and behavior. In other words, ASD provides basic interest for the participants to support the related charitable organization. Second, the Organization for Autism Research is one of the most visible ASD related organizations that helps individuals with autism and provides assistance to parents, families, teachers and caregivers. The goal of OAR is clear and reputable so participants won't question the authenticity of our message's motive. Finally, we wished to avoid a charity associated with a life-threatening condition such as cancer as it may create an experimental confound: we don't know if some donates because their intrinsic desire to help with a life-threatening condition. While ASD can have serious consequences on the well being of those who have it, the public perception is that ASD is not-life threatening.

Persuasive Messages. The persuasive messages communicate three major objectives, 1) Participants will have 10 % of chance winning $ 5 bonus upon the completion of the study. 2) Participants are free to use the money as they please. and 3) Participants can donate this bonus to the Organization for Autism Research (OAR). Therefore, in the text condition, study participants will read the following message,

> *You have a 10% chance of winning a five dollar bonus in this study. You are free to use this money as you please. If you win the prize, would you like to donate to support the Organization for Autism Research?*

In the two comic conditions, instead of creating a single panel comic as in the first study, we created three-panel comic strips to communicate the message. The three-panel comic strip allows us to leverage one of the most fascinating aspect of comics—storytelling [21]. Since the first study did not show a convincing effect for framing, participant gesture, character distance and shading, we did not vary those conditions in this experiment. We set the inter-character distance to be medium, light background. However, consistent with "match on action" technique [21], we matched the panels on the gesture of the first character (the message recipient), while retaining a neutral gesture for the second character (who delivers the message). We create the comic strip in a manner similar to the first study on preference.

In the social-proof-comic condition, we created social-proof by adding one sentence on the last comic panel indicates the percentage of people in our study donated see Figure 6. The percentage (87%) corresponds to the number of people who donated a non-zero amount in the pilot study.

Participants. We published our HITs on Amazon Mechanical Turk titled "A short survey about communicating autism campaign ads." Similar to the Study 1, the compensation was $8/hr, and the workers would get these rewards regardless of their performance, the threshold for participant to join was

a 95% Approval Rate. On the HIT page, we instructed that repeated responses would be rejected. We told the participants that they would see a link to our experiment site.

7 STUDY ON PERSUASION: RESULTS

Raw Data

In total we have 307 participants joined our study, 101 participants received the message in the text form, 102 participants received the same message in the comic form, and 104 participants received the comic message with social-proof. We ran an outlier analysis on participants' completion time and removed 30 participants from our dataset. The following analysis is based on a dataset with 277 participants, 91 of them is in pure-text condition, 97 of them is in comic condition, and 92 of them is in comic-social-proof condition. Of those 277 participants, 150 were self-identified as male, and 126 were self-identified as female, 1 participant chose not to disclose. 197 participants earned at least college degree.

Analysis

Now, we discuss our Bayesian formulation. There is one outcome variable $y_{i|j}$, the amount of donation to the charity by each participant i, under experimental condition j: text, comic, and comic with social norm. Our Bayesian model:

$$y_{i|j} \sim \text{StudentT}(\nu, \mu_j, \sigma_j), \tag{9}$$

$$\nu \sim \exp(\lambda), \tag{10}$$

$$\mu_j \sim N(a, b), \tag{11}$$

$$\sigma_j \sim U(L, H). \tag{12}$$

We use a StudentT distribution with ν degrees of freedom to model the random variable; notice that this is a *drawing distribution*, not the t-test. The StudentT allows us to model a non-Normal outcome with a heavy tail; assuming $y_{i|j}$ to be Normally distributed is equivalent to setting $\nu = \infty$. The degrees of freedom ν is drawn from an exponential distribution; the mode μ_j corresponding to each experimental group is drawn from a Normal distribution; the "width" σ_j of the t-distribution corresponding to group j is drawn from an uniform distribution. The hyper-priors for variables ν, μ_j and σ_j are set to be generous to allow for wide variation in these values. For example, we set $\lambda = 1/29$, since $\nu \geq 30$ is a rule of thumb for presence of Normality.

The result Figure 7 shows the modal effect size between abstract-comic v. pure-text = 0.48; There is no overlap of the 95% high probability density (HPD) interval with the ROPE of [-0.1, 0.1]. Thus the effect is of medium size and meaningful; the effect size between abstract-comic and social-proof-comic is 0.12; but since the distribution includes a ROPE of $[-0.1 \pm 0.1]$, the effect is not convincing.

In this section, we presented a Bayesian model to analyze the overall effect of using a abstract-comic to persuade people making charitable donation decisions, and understand the effect of adapting persuasive techniques in the abstract comic form. The results show that the use of abstract-comic produces a significant effect in persuading participants to donate. Although abstract-comic with social proof can produce larger effect, the contrast between abstract-comic and abstract-comic with social proof is not significant. Next we discuss the findings, limitations and design implications.

8 DISCUSSION

Here we first summarize our findings from both studies. Then we discuss the effect on Inter-character Distance, the limitations of study, and the design implications.

Our results show that subjects prefer persuasive messages in comic form over plain text. We found in a persuasive comic, information framing, character gestures, background shading do have a minor, but non-significant effect on preference of the comic. In the second study, we further examined the persuasive power of the abstract comic in real-life decision making. The results demonstrate the persuasive power of abstract comic in nudging people to engage in pro-social behavioral decisions, i.e. charitable giving. Our findings are consistent with prior research on visual stimulus in persuasion and the benefits of comics in communication.

Limitations

No interaction effects in model : Our model does not include any interaction effects. This is by design, since in the first study we have 54 experimental conditions making the any analysis interaction effects difficult with our small observational study. The raw data suggests an interaction between shading and gesture, but given our limited dataset, there is little point in modeling this interaction. We plan to study interaction effects in future studies by limiting the number of main predictor conditions.

Generalizability : Although our second study asked participants to make decision with cost, the decision domain is limited to only one scenario, charitable giving. We need more studies to evaluate persuasiveness of abstract comics in other domains.

Ecological Validity: There is a legitimate question if our experiment on Amazon Mechanical Turk has ecological validity. In real life, many factors affect a persons decision, such as where they are and who they are interacting with. Those factors may interact with the abstract comic's persuasiveness. However, these concerns are also present in other standard studies conducted in the more familiar lab experiments. We

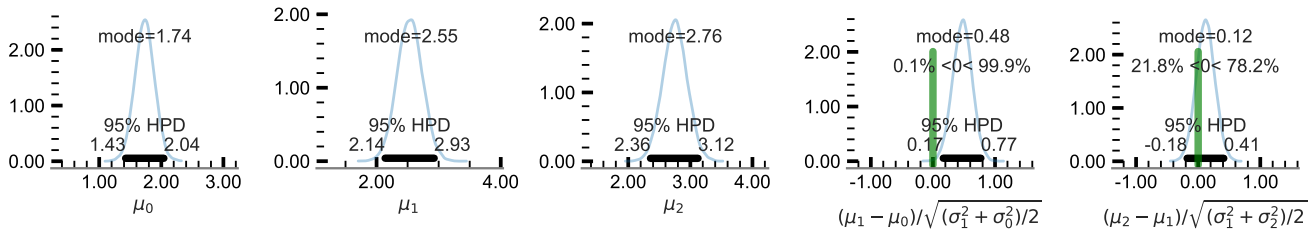

Figure 7: The posterior distribution of the amount of money participants decide to donate to the charity in each of the three conditions: text only (μ_0); comic (μ_1); comic with social norm (μ_2). The right two panels are respectively: posterior distribution of the effect size contrasting the comic condition (μ_1) and text (μ_0); the effect size contrasting comic with social norm (μ_2) with the plain comic (μ_1). First notice that $\mu_2 > \mu_1 > \mu_0$. Furthermore, the modal effect size of comparing the comic panel against text is 0.48, a medium effect and the HPD interval $[0.17, 0.77]$ reliably excludes a ROPE of $[0 \pm 0.1]$, indicating that the effect is meaningful. The effect of introducing the social norm into the comic has a minor effect (mode=0.12) when contrasted against the plan comic, and the HPD interval $[-0.17, 0.41]$ includes a ROPE of $[0 \pm 0.1]$, indicating that the outcome is not convincing.

plan to conduct field studies in real-world contexts (e.g. shopping at a grocery store) to explore this issue.

Appropriate gestures : The authors determined gestures used by the characters in the experiment through trial and error. It may be useful to examine theoretical frameworks from dance as well as theater art forms as well as examine work on design of sign languages.

Design Implications

The main implication of our study lies in how to deliver persuasive messages. Given the increasing popularity of wearable devices including smartwatches, one could consider presenting persuasive messages in the form of an abstract comic, where the three panel comic is shown in sequence, perhaps even in animation.

The framework that we have described in this paper for the comic is amenable for algorithmic synthesis: the behavioral data informs the text and character gestures. We could derive the statistics for the social norm from behaviors of friends and the data from a person's own activity for information framing, and map the data to the character gesture, thus reinforcing the framing. While both information framing and the use of the social proof improve the comic persuasiveness, our studies indicate the comic form is more important. Thus, we expect the comic form to be useful, even if behavioral data or social norms are unavailable.

9 CONCLUSION

This paper examined if the abstract comic form was more persuasive that the corresponding plain text. Furthermore, we examined how elements of the comic—gesture, inter-character distance and shading—influenced the effect of the comic. Three ideas were key to our work: "social proof" (that we adopt behaviors of our friends or people similar to us), "information framing" (individuals have asymmetric utility functions), and the role of abstract comics to allow readers to project themselves onto the comic.

We conducted two empirical studies on Amazon Mechanical Turk. The first study examined if the abstract comic form was preferred to text; the second study on charitable giving examined if the abstract comic form was more persuasive than text. In both cases, we analyzed the results using a hierarchical Bayesian framework that allows for understanding effect sizes, as well are helpful in small-n studies. The results from the first study show that the abstract comic form is preferred to text (effect size=0.32; a moderate effect). Information framing, character gesture, character distance, and shading do have minor effects, but these are not meaningful. The second study shows convincingly that the three-panel comic is more persuasive than the text (medium effect size=0.48). The presence of the social proof is also effective, but provides only a minor improvement to the use of the abstract comic (effect size =0.12; not a meaningful improvement). The main implications of our work lie in how persuasive messages are delivered, especially to wearable devices.

As next steps, we plan to develop an algorithmic framework that automatically maps a person's behavioral data (e.g. amount walked this week) to the three panel comic. We also plan to conduct longitudinal field experiments with an emphasis on storytelling where individuals receive three-panel comics over time, but the panels are connected with a storyline.

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