

Storytelling Agents with Personality and Adaptivity

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Abstract. We explore the expression of personality and adaptivity through the gestures of virtual agents in a storytelling task. We conduct two experiments using four different dialogic stories. We manipulate agent personality on the extraversion scale, whether the agents adapt to one another in their gestural performance and agent gender. Our results show that subjects are able to perceive the intended variation in extraversion between different virtual agents, independently of the story they are telling and the gender of the agent. A second study shows that subjects also prefer adaptive to nonadaptive virtual agents.

Keywords: personality, gesture generation and variation, gestural adaptation, story telling, collaborative story telling

1 Introduction

It is a truism that every person is a unique individual. However, when interacting with or observing others, people make inferences that generalize from specific, observed behaviors to explanations for those behaviors in terms of dispositional traits [1]. One theory that attempts to account for such inferences is the Big Five theory of personality, which posits that consistent patterns in the way individuals behave, feel, and think across different situations, can be described in terms of trait adjectives, such as sociable, shy, trustworthy, disorganized or imaginative [2, 3].

Previous work suggests both that personality traits are *real*, and that they are *useful* as a basis for models for Intelligent Virtual Agents (IVAs) for a range of applications [4–8]. Many findings about how people perceive other humans appear to carry over to their perceptions of IVAs [9–13]. Research suggests that human users are more engaged and thus learn more when interacting with characters endowed with personality and emotions, and that a character’s personality, surprisingly, affects users’ perceptions of the system’s competence [14, 15]. Recent experiments show that the Big Five theory is a useful basis for multi-modal integration of nonverbal and linguistic behavior, and that automatically generated variations in personality are perceived as intended [16–19].

However, personality is not expressed in a void. Conversants dynamically adapt to their conversational partner, both in conversation and when telling stories, and using both verbal and nonverbal features [20–24], *inter alia*. There is also evidence that people prefer IVAs that align with human behavior, such as by mimicking head movements [22] or speech style [11]. A human’s attraction to an IVA is increased when the IVA adapts its personality to the human over time rather than maintaining a consistently similar personality [11]. Inspired by previous work, this paper:

- Introduces a novel task of two IVAs co-telling a story;
- Varies IVA personality through gestural parameters of gesture rate, speed, expanse and form.

- Varies whether the IVAs adapt to one another’s gestures in gesture rate, speed, expanse and form and use of specific gestures.
- Tests the effect of, and interaction between, these variations with human perceptual experiments and report our results.

Our stories come from weblogs of personal narratives [25] whose content has been regenerated as dialogues to support story co-telling. Example dialogs from the four we use in our experiments are in Fig. 1 and Fig. 5 in Sec. 3. These dialogs have a fixed linguistic representation and use oral language, discourse markers, shorter sentences, and repetitions and confirmations between speakers, as well as techniques to make the story sound like the two speakers experienced the event together. Our aim is to mimic the finding that storytelling in the wild is naturally conversational [24], and that the style of oral storytelling among friends varies depending on their personalities [24].

We carry out two experiments. In the personality experiment, we elicit subjects’ perceptions of two virtual agents designed to have different personalities. In the gestural adaptation experiment, we ask whether subjects prefer adaptive vs. non adaptive agents. Our results show that agents intended to be extroverted or introverted are perceived as such, and that subjects prefer adaptive stories. Sec. 2 describes our story dialog corpus. Sec. 3 and 4 presents our experimental design and results. In order to compare more concisely with our work, we delay discussion of related work until Sec. 5, where we discuss our results and describe future work.

2 Story Dialog Corpus

We first annotate dialogs with a general underspecified gesture representation, then we prepare several versions of each dialog by varying experimental parameters such as agent extraversion and adaptivity.

Gesture Annotation We build on Neff et al.’s work on the impact of extraversion on gesture in IVAs [17], as shown in Table 1, and select parameters to depict both introverted and extraverted IVAs by varying gesture amplitude, direction, rate and speed. We test user perceptions of IVA personality during story co-telling without adaptation, and then test whether we can achieve effects on personality perception when IVAs adapt to one another.

Protest Story	
A1:	Hey, do you remember that day? It was a work day, I remember there was some big event going on.
B1:	Yeah, that day was the start of the G20 summit. It’s an event that happens every year.
A2:	Oh yeah, right, it’s that meeting where 20 of the leaders of the world come together. They talk about how to run their governments effectively.
B2:	Yeah, exactly. There were many leaders coming together. They had some pretty different ideas about what’s the best way to run a government.
A3:	And the people who follow the governments also have different ideas. Whenever world leaders meet, there will be protesters expressing different opinions. I remember the protest that happened just along the street where we work.
B3:	It looked peaceful at the beginning....
A4:	Right, until a bunch of people started rebelling and creating a riot.
B4:	Oh my gosh, it was such a riot, police cars were burned, and things were thrown at cops.
A5:	Police were in full riot gear to stop the violence.
B5:	Yeah, they were. When things got worse, the protesters smashed the windows of stores.
A6:	Uh huh. And then police fired tear gas and bean bag bullets.
B6:	That’s right, tear gas and bean bag bullets... It all happened right in front of our store.
A7:	That’s so scary.
B7:	It was kind of scary, but I had never seen a riot before, so it was kind of interesting for me.

Fig. 1. Protest Dialogue, with fixed level of linguistic adaptation.

Parameter	Introvert Findings	Extravert Findings
Gesture amplitude	narrow	wide, broad
Gesture direction	inward, self-contact	outward, table-plane and horizontal spreading gesture
Gesture rate	low	high, more movements of head, hands and legs
Gesture speed, response time	slow	fast, quick
Gesture connection	low smoothness, rhythm disturbance	smooth, fluent
Body part		head tilt, shoulder erect, chest forward, limbs spread, elbows away from body, hands away from body, legs apart, legs leaning, bouncing, shaking of legs

Table 1. The gestural correlates of extraversion.

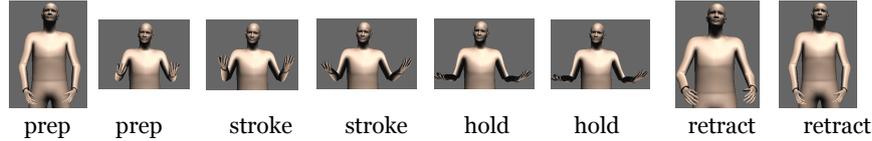


Fig. 2. Prep, stroke, hold and retract phases of gesture Cup_Horizontal.

We construct the dialogs for the two IVAs manually from the monolog weblogs. We then generate audio for the utterances of each IVA using the AT&T Text to Speech engine (female voice Crystal and male voice Mike). We annotate the dialogs with a general, underspecified gestural representation, specifying both potential gestures and gesture placements. This representation allows us to procedurally generate hundreds of possible combinations of story co-tellings varying both gestural performance (personality) and adaptation. Annotators can insert a gesture when the dialog introduces new concepts, and add gesture adaptation (mimicry) when there are repetitions or confirmations in the dialog. The decisions of where to insert a gesture and which gesture to insert are mainly subjective. We use gestures from a database of 271 motion captured gestures, including metaphoric, iconic, deictic and beat gestures. Fig. 2 illustrates how every gesture can be generated to include up to 4 phases [26]:

- prep: move arms from default resting position or the end point of the last gesture to the start position of the stroke
- stroke: perform the movement that conveys most of the gesture’s meaning
- hold: remain at the final position in the stroke
- retract: move arms from the previous position to a default resting position

Fig. 3 shows the first 5 turns of the protest story annotated with gestures. The timing information of the gestures comes from the TTS audio timeline. Each gesture annotation

A1: [1.90s](Cup, RH 0.46s) Hey, do you remember [3.17s](PointingAbstract, RH 0.37s) that day? It was a [4.97s](Cup_Horizontal, 2H 0.57s) work day, I remember there was some big event [7.23s](SweepSide1, RH 0.35s) going on.
B1: Yeah, that day was the start of [9.43s](Cup_Down.alt, 2H 0.21s) the G20 summit. It’s an event that happens [12.55s](CupBeats.Small, 2H 0.37s) every year.
A2: Oh yeah, [14.2s](Cup.Vert, RH 0.54s) right, it’s that meeting where 20 of the leaders of the world [17.31s](Regressive, RH 1.14s) come together. They talk about how to run their governments [20.72s](Cup, RH 0.46s) effectively.
B2: Yeah, [22.08s](Cup.Up, 2H 0.34s) exactly. There were many leaders [24.38s](Regressive, LH 1.14s/Eruptive, LH 0.76s) coming together. They had some pretty [26.77s](WeighOptions, 2H 0.6s) different ideas about what’s the best way to [29.13s](Cup, RH 0.46s/ShortProgressive, RH 0.38s) run a government.
A3: And [30.25s](PointingAbstract, RH 0.37s) the people who follow the governments also have [32.56s](WeighOptions, 2H 0.6s/Cup, 2H 0.46s) different ideas. Whenever [34.67s](Cup.Up, 2H 0.34s/Dismiss, 2H 0.47s) world leaders meet, there will be protesters expressing [37.80s](Away, 2H 0.4s) different opinions. I remember the [39.87s](Reject, RH 0.44s) protest that happened just [41.28s](SideArc, 2H 0.57s) along the street where we work.
B3:

Fig. 3. Sample blog story dialog with gesture annotations (two versions). Format of annotation: [gesture stroke begin time](gesture name, hand use, gesture stroke duration).

contains information in the following format: [gesture stroke begin time](gesture name, hand use, stroke duration). For example, in the first gesture “[1.90s](Cup, RH 0.46s)”, gesture stroke begins at 1.9 seconds of the dialog audio, it is a Cup gesture, uses the right hand, and the gesture stroke lasts 0.46 seconds. Research has shown that people prefer gestures occurring earlier than the accompanying speech [27]. Thus in this annotation, a gesture stroke is positioned 0.2 seconds before the beginning of the gesture’s following word. For example, the first word after gesture “Cup” is “Hey”, it begins at 2.1 seconds, then the stroke of gesture “Cup” begins at 1.9 seconds.

Our gesture annotation does not specify features associated with particular gestures (i.e. gesture amplitude, direction and speed). But these features can be easily adjusted in our animation software, which can vary the amplitude, direction and speed. The default gesture annotation frequency is designed for extraverts, with a gesture rate of 1 - 2 gestures per sentence. For an introverted agent, a lower gesture rate is achieved by removing some of the gestures. In this way, both speakers’ gestural performance can vary from introverted to extraverted using the whole scale of parameter values for every parameter.

In addition, we can also vary gestural adaptation in the annotation. In extravert & extravert gestural adaptation (based on the model described in [28]), two extraverts move together towards a more extraverted personality. Gesture rate is increased by adding extra gestures (marked with an asterisk “*”). Specific gestures are copied as part of adaptation, especially when the co-telling involves repetition and confirmation. Gestures in bold indicate copying of gesture form (adaptation), gestures after the slash “/” are non-adapted. Combined with personality variations for gestures described in the previous paragraph, it is possible to produce combinations of two agents with any level of extraversion engaged in a conversation with or without gestural adaptation.

Stimulus Construction We currently have 50 annotated story dialogs. In this experiment, we use four stories with different subject matter: protest, pet, storm and gardening, as illustrated in Fig. 1 and Fig. 5. Fig. 4 shows a screenshot of the stimuli. We use our own animation software to generate the stimuli based on the specified gesture script. This software uses motion captured data for the wrist path, hand shape and hand orientation for each gesture stroke, motion captured data for body movement, and spline based interpolation for preparation and retractions. It also uses simplified physical simulation to add nuance to the motion. A gesture contains up to 4 phases: prep, stroke, hold and retract: we insert a hold and connecting prep between two strokes if they are less than 2.5 seconds away from each other. Otherwise, we insert a retraction.



Fig. 4. A snapshot of the experimental stimuli.

The animation software takes as input scripts specifying gesture sequences, along with modifying edits (specifying features such as gesture amplitude, direction and speed), and produces an animation meeting the constraints as output. This is exported as a bvh file, that is then imported into Maya for rendering on the final model. In the video, two IVAs stand almost face-to-face, but each has an 55° angle “cheat” towards the audience, as is commonly used in stage performances. We also add background body

movements [29] and head rotation movements for both agents. Both of these are kept constant for each stimuli pair.

3 Experiment Method

We conduct two separate experiments, one on personality variation during co-telling a story, and the second using the same personalities but with and without adaptation.

Experiment 1: Personality Variation.

We prepared two versions of the video of the story co-telling for each of the four stories, one where the female is extraverted (higher values for gesture rate, gesture expanse, height, outwardness, speed and scale) and the male is introverted (lower values for those gesture features) and one where only the genders (virtual agent model and voice) of the agents are switched. The dialogue scripts and corresponding gesture forms do not vary from one co-telling to another. This results in 8 video stimuli for four stories.

We conducted a between-subjects experiment on Mechanical Turk where we first ask Turkers to answer the TIPI [30] personality survey for themselves, and then answer it for only one of the agents in the video, after watching the video as many times as they like. Thus for each video stimulus, there are two surveys. We ran our 16 surveys as 16 HITs (Human Intelligence Tasks) on Mechanical Turk, requesting 20 subjects per HIT (each worker can only do one of the tasks), which results in 320 judgements. The average completion time for the 8 HITs on Mechanical Turk was 5 minutes 15 seconds. The average stimulus length was 1 minute 32 seconds. Since the survey is hosted outside Mechanical Turk, sometimes we get more than 20 subjects for each HIT.

Experiment 2: Gestural Adaptation. For the adaptive experiment, both agents are designed to be extroverted. We chose to use two extraverted agents because we have foundations from previous work showing the adaptation model between two extraverted speakers [28] (where both agents become more extraverted). We use only a part of each story for one experimental task. The stimuli for one task has two variations: adapted and non-adapted. Both stimuli use the same audio, contain 2 to 4 dialog turns with the same gestures as an introduction to the story (which we refer to as context), and the next (and last) dialog turn with gesture adaptation or without gesture adaptation (which we refer to as response). Adaptation only begins to occur in the last dialog turn. In this way, subjects can get to know the story through the context, and compare the responses to decide whether they like the adapted or non-adapted version.

Pet Story	
A1:	I have always felt like I was a dog person but our two cats are great. They are much more low maintenance than dogs are.
B1:	Yeah, I'm really glad we got our first one at a no-kill shelter.
A2:	I had wanted a little kitty, but the only baby kitten they had scratched the crap out of me the minute I picked it up so that was a big "NO".
B2:	Well, the no-kill shelter also had what they called "teenagers", which were cats around four to six months old...a bit bigger than the little kitties.
A3:	Oh yeah, I saw those "teenagers". They weren't exactly adults, but they were a bit bigger than the little kittens.
B3:	Yeah one of them really stood out to me then- mostly because she jumped up on a shelf behind us and smacked me in the head with her paw.
A4:	Yeah, we definitely had a winner!
B4:	I had no idea how much personality a cat can have. Our first kitty loves playing. She will play until she is out of breath.
A5:	Yeah, and then after playing for a long time she likes to look at you like she's saying, "Just give me a minute, I'll get my breath back and be good to go."
B5:	Sometimes I wish I had that much enthusiasm for anything in my life.
A6:	Yeah, me too. Man, she has so much enthusiasm for chasing string too! To her it's the best thing ever. Well ok, maybe it runs a close second to hair scrunchies.
B6:	Oh I love playing fetch with her with hair scrunchies!
A7:	Yeah, you can just throw the scrunchies down the stairs and she runs at top speed to fetch them. And she always does this until she's out of breath!
B7:	If only I could work out that hard before I was out of breath... I'd probably be thinner.

Fig. 5. Pet Dialogue, with fixed level of linguistic adaptation.

- Non-adapted: In the last dialog turn, the extraverted agent maintains his or her gesture rate (1 - 2 gestures per sentence), expanse, height, outwardness, speed and scale. There is no copying of specific gestures.
- Adapted: In the last dialog turn, the extraverted agent increases the gesture rate (1 - 3 gestures per sentence), expanse (18 cm further from center), height (10 cm higher), outwardness (10 cm more outward), speed (1.25 times faster) and scale (1.5 times larger). Fig. 6 shows the same gesture with different expanses and heights. In the adapted version, specific gestures are copied (e.g. gestures in bold font in Fig.3).

Thus every story has two versions. One version ends with the female agent’s response, another ends with the male agent’s response. For example, Garden ABA has three turns, ending with the female agent adapting to the male, and



Fig. 6. Virtual agent with different gesture expanse and height for the same gesture.

Garden ABAB has four turns, ending with the male agent adapting to the female. Every version consists of two conditions (adapted and non-adapted versions) and a short survey. The order of the two conditions is random for every participant. But there is a letter mark assigned to every video for easy reference (see Fig. 4).

Subjects are asked to watch the two stimuli first, and then finish the survey. Subjects are told that the audio of the two videos is the same, but only the last few gestures of the female/male agent are different. Subjects are also advised to watch the video as many times as they want. The survey has two questions: (1) Which video is a better story co-telling based on the gestures? (2) Please explain the reason behind your choice to the previous question (which we refer to as the “why” question). Our primary aim is to determine whether people perceive the adaptation and whether it makes a better story.

We ran our 8 tasks for 4 stories as 8 HITs on Mechanical Turk, requesting 25 subjects per task. The average completion time for the 8 tasks on Mechanical Turk was 2 minutes 53 seconds. The average stimulus length was 35.3 seconds. This means that, on average, a subject spent 1 minute 43 seconds answering the questions. We removed subjects who failed to state their reasons of preference in the “why” question.

4 Experimental Results

4.1 Personality Results

We conducted a three-way ANOVA with agent intended personality, agent gender and story as independent variables and perceived agent personality as the dependent variable. See Table 2. The results show that subjects clearly perceive the intended extraverted or intended introverted personality of the two agents ($F = 67.1$, $p < .001$). There is no main effect for story (as intended in our design), but there is an interaction effect between story and intended personality, with the introverted agent in the storm story being seen as much more introverted

Story	Intro-Agent	Extra-Agent
Garden	4.2	5.4
Pet	4.7	5.0
Protest	4.2	5.3
Storm	3.7	5.7

Table 2. Experiment results: participant evaluated extraversion scores (range from 1 - 7, with 1 being the most introverted and 7 being the most extraverted).

than in the other stories ($F=7.5$, $p < .001$). There is no significant variation by agent gender ($F = 2.3$, $p = .14$).

Since previous work suggests that personality is perceived for an agent along all Big Five dimensions whether it is designed to be manifest or not [16, 31], we also conducted a two-way ANOVA by story and agent intended personality for the other 4 traits. There are no significant differences for Conscientiousness, or Openness. However Introverted agents are seen as more agreeable ($p = .008$) and more emotionally stable ($p = .016$). There were no significant differences by story except that both agents in the Storm story were seen as less open, presumably because the content of the story is about how scary the storm is.

4.2 Adaption Results

The results in Table 3 show that across all the videos, the mean percentage of people who preferred the adapted version was 64% (19% standard deviation), which is marginally better than a predicted preference of 50%, $t(7) = 2.15$, $p = .07$. Analysis of participants' descriptions of why they preferred one video over another shows 4 distinct categories of reasons of why people made their choices (see Table 4).

Subjects who preferred the adapted versions said that the gestures fit the dialog better ("adapted good gestures" in Table 4): the subjects stated that the adapted versions had gestures that "flowed better with the words", were "more natural", "more appropriate to what he said", and "relevant to the dialog", and that they "could imagine a friend making various hand gestures similar" to the ones in the story. Another reason was that gestures were "more animated" ("adapted animated"): the adapted version had "more hand gestures", and the agent "used his arms more", "gestured more", and "was much more alive". In contrast, in the non-adapted version, the agent "seemed very bored" and "wanted to end the conversation". This indicates that the subjects preferred agents with a higher gesture rate. Ten subjects commented on the expanse, height, scale and speed of the gestures: they chose the adapted version because the agent "gestured higher in the air", "making wider, grander gestures" that were "more expansive" and "bigger". And in the non-adapted version, the gestures were "too slow". However, there was no comment about the copying of gestures, possibly because copying was less obvious when the expanse and height of the gestures changed in the adapted version.

Among those who preferred the non-adapted versions of the stories, one reason was that the gestures fit the dialog better ("non-adapted good gestures" in Table 4): the subjects stated that the gestures in the non-adapted version "went a lot better with what she was saying" and were "more appropriate". Another reason is that the gestures were "more realistic" ("non-adapted realistic"): subjects didn't like the gestures being "too animated", or "too busy", nor did they like the agents "showing way too much

Story Version	#A	#NA	%A	%NA
Garden ABA	11	9	55%	45%
Garden ABAB	20	2	91%	9%
Pet ABABA	10	13	43%	57%
Pet ABABAB	19	5	79%	21%
Protest ABAB	8	11	42%	58%
Protest ABABA	11	11	50%	50%
Storm ABABA	16	4	80%	20%
Storm ABABAB	14	5	74%	26%
Total	109	60	64%	36%

Table 3. Experiment results: number and percentage of subjects who preferred the adapted (A) stimulus and the non-adapted (NA) stimulus. The letters in the story version refer to dialog turns by speaker A or B. For example, ABA means A takes dialog turns 1 and 3 in the stimuli, while B takes dialog turn 2.

emotions” or “looking like she is exercising”. That is, too much animation can be seen as unrealistic.

The percentages of the subjects that had comments related to those 4 categories are in Table 4. In 7 out of 8 tasks, there were more subjects who preferred the adapted version because it was animated at the right level (e.g. animated enough, but not too animated). If we only consider the “animated” factor in deciding which is a better stimulus, 84% of the subjects preferred the adapted version.

Story Version	%A good gest	%NA good gest	%A animated	%NA realistic
Garden ABA	30%	30%	20%	30%
Garden ABAB	41%	9%	59%	0%
Pet ABABA	22%	43%	13%	9%
Pet ABABAB	54%	13%	33%	0%
Protest ABAB	21%	32%	26%	0%
Protest ABABA	27%	32%	23%	9%
Storm ABABA	20%	15%	45%	0%
Storm ABABAB	32%	21%	47%	0%
Total	31%	24%	33%	6%

5 Discussion and Future Work

To our knowledge this is the first time that it has been shown that subjects perceive differences in agent personal-

ity during a storytelling task, and that adaptive gestural behavior during storytelling is positively perceived. We re-use natural personal narratives that are rendered dialogically, so that two IVAs co-tell the story.

It is obvious that being able to adapt is a key part of being more human-like. There are attempts to integrate language adaptation within natural language generation [32] and research has shown that human bystanders perceive linguistic adaptation positively [33]. However, this is the first experiment to demonstrate a positive effect for gestural adaptation.

Recent work on gesture generation has focused largely on iconic gesture generation. For example, Bergmann and Kopp [34] present a model that allows virtual agents to automatically select the content and derive the form of coordinated language and iconic gestures. Luo et al. [29] also presents an effective algorithm for adding full body postural movement to animation sequences of arm gestures. More generally, current systems generally select gestures using either a text-to-gesture or concept-to-gesture mapping. Text-to-gesture systems, such as VHP [13], may have a limited number of gestures (only 7 in this case) and limited gesture placement options, but the alignment of speech content and gestures are more accurate. Concept-to-gesture systems such as PPP [35], AC and BEAT [36] defines general rules for gesture insertion based on linguistic components. For example, iconic gestures are triggered by words with spatial or concrete context (e.g. “check”). These kind of systems have more gestures, but the gesture placement largely depends on general rules derived from literature, thus the accuracy is not guaranteed. An alternative approach learns a personalized statistical model that predicts a gesture given the text to be spoken and a model that captures an individual’s gesturing preferences [37]. None of these models adequately address the production of gesture for dialogues, where a process of co-adaptation will modulate both the type of gesture chosen and the specific form of that gesture (e.g. its size). This current work aims to provide a basis for developing such models.

Table 4. Answers to the second survey question (“why” question) classified into categories. Note that one subject could belong to none or multiple categories, so the percentages for each line don’t add up to 100%.

Gratch investigates creating rapport with virtual agents using gesture adaptation mainly focused on head gestures and posture shifts (while ours focused on hand gestures), and used real human movements as control [38]. Our adaptation stimuli are more similar to Endrass et al. [12]. To investigate culture-related aspects of behavior for virtual characters, they chose prototypical body postures from corpora for German and Japanese cultural background, embodied those postures in a two-agent dialogs, and asked subjects from German and Japanese cultural background to evaluate the dialogs.

In future work, we aim to test the expression of personality and adaptivity with different personality combinations. Our ultimate goal is to automatically convert monologic blog stories to dialogs with both linguistic and gestural adaptation. Experimental exploration, such as undertaken here, is crucial for formulating models of gesture generation that correctly incorporate personality and adaptation.

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