COMPUTER SCIENCE

# Virtually Trustworthy

How online personas are designed may increase the impression of trustworthiness, but that does not make the information conveyed more reliable.

**Judith Donath**

Our impression of others in face-to-face interactions derives from multimodal observations: We hear voices, see faces and gestures, and listen to each other's words. Our online interactions are less sensory, dominated instead by text: We send e-mail, read discussion boards, and participate in text chats. Yet that may be changing. Online 3D spaces such as *There* and *Second Life* feature detailed virtual environments in which users represent themselves with graphical avatars, often highly customizable.

Avatars may closely resemble a person, or they may be fantastical creations such as aliens or talking lizards. Their online use dates back to the mid-1980s, when they were used in games such as *Ultima* and in the online social space *Habitat*. As technology has advanced, they have gone from being static 2D images to complex 3D animations, complete with realistic gait, fashionable clothing, and dynamic facial expressions.

The challenge in creating more sophisticated avatars lies partly in the domain of computer graphics, such as better rendering of hair and fabric or more lifelike gait kinematics. Yet there is also a substantial social element: getting the avatar to interact with others gracefully and realistically. For example, if an avatar is rendered with detailed eyes, then appropriate gaze direction is essential. All such behaviors, which are taken for granted in face-to-face interaction, must be explicitly coded into the avatar.

We carry out social interactions with a large number of communicative behaviors that indicate our intention, state of mind, communicative competency, and so on. For instance, you may see an acquaintance across the room at a cocktail party and decide to go speak to him. You carry out this goal not only by walking across the room but also by making eye contact, smiling, raising your brows, adjusting your clothes—a complex set of communicative behaviors that indicate your intention to start a conversation, allow you to gauge his willingness to do so, and show your level of determination. Cassell and Vilhjálmsson (*1*) argued that avatars without these social behaviors seem stilted and awkward. They can be moved to stand next to each other to talk, but stare blankly into space, inert and unengaged.

Just giving the user finer control over the avatar is not a satisfactory option, however, for if users must specify their avatar's every eye movement and gesture, they would be too distracted to engage in the conversation itself. Cassell and Vilhjálmsson's solution was to program such behaviors into the avatars, to be set off when the user indicated some desired action. For instance, if the user indicated (with a simple typed command) that she wanted to end a conversation, the avatar would break away by averting its gaze, and upon leaving would look at its recent partner, nod its head, and wave. Users of this system found it more natural and engaging than one with static avatars and felt that their conversational partners were more expressive.

Researchers have found that users infer a number of character traits from avatar behavior and appearance. They judge avatars that are humanlike and clearly gendered (as opposed to androgynous) to be the most attractive and the most credible (*2*). In an audio-only conversation, simply adding an avatar whose head and eye movements match the conversation flow increases users' perception of their partners' trustworthiness and friendliness.

Today's online graphical interactions are still rather awkward. Behavioral sophistication lags behind rendering skill, so we have avatars whose appearance raises high expectations of humanlike behaviors but whose gaze and gestures are relatively primitive. However, it is quite conceivable that in a few years avatars whose behavior is nearly imperceptible from humans' will be available.

**Held in trust.** Self presentation in real and virtual life.

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Yet this raises important questions about the reliability of the impressions we form in avatar-mediated interactions. In our face-to-face interactions, many of the cues we read to assess traits such as trustworthiness have real links to the trait. Gaze direction, for example, links directly to what one is seeing. When long averted, it is thus a sign of inattention. During times of high cognitive load, such as when inventing a story, people may make less eye contact, possibly because gazing at another face is itself a cognitively intensive process. Perhaps because of this, we have the popular (though unsubstantiated) belief that someone who makes steady and direct eye contact is being honest (*3*).

Online, however, behaviors generated by a software program can create the same impression of trustworthiness or friendliness, but without a grounding connection to an underlying cognitive process or other causative element. As behavioral software becomes more sophisticated, are we creating avatars that will be increasingly attractive and seemingly friendly but are in fact the ideal mask behind which a dishonest or manipulative person can operate? Once an interface includes humanlike avatars, the issue of user interpretation of character traits from ungrounded avatar behaviors is inevitable, for even nonaction is an interpretable behavior; it conveys an impression of social ineptness and distance.

How we assess these issues depends on the context in which they are used and how we view them in relation to real-world practice. In the real world, we use many strategies to enhance the impression we make on others. We employ resume consultants and speech coaches, wear makeup, and undergo plastic surgery. In the virtual realm, idealized bodies and perfect skin are the norm (*2*), but there are also a whole new range of possible enhancements. Bailenson and colleagues have conducted several experiments on digital mimicry, such as morphing a person's own face into the avatar of their conversational partner or having that avatar closely mimic their ges-

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tures (*4*). They found that people in a group paid closer attention to messages delivered by a "team face" avatar, made by combining the features of the people in the group. This could be a useful technique for enhancing the cohesiveness of geographically dispersed groups. Yet they also found that politicians' arguments were more persuasive when their faces were made to subtly resemble the listener's, raising the specter of a world in which you are bombarded with oddly compelling ad campaigns presented by people just like you.

Reliability involves tradeoffs. Less reliable communication is often cheaper or easier; when deception becomes too prevalent, more costly signals or social sanctions may be needed (*5*). Suspicious citizens of the future may demand to interact with candidates only through trusted "manipulation-free" sites. Today, most 3D graphical sites are fantasy games, where role-playing and artifice are not only accepted but also required. As social sites such as *Second Life* gain popularity, other uses are emerging, including academic lectures, retail stores, and business meetings. These will require a range of avatar designs, not only in terms of technical sophistication but also across a continuum from the most attractive and impressively persuasive to the most rigorously and reliably grounded.

**References**

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CHEMISTRY

# Shining Light on the Rapidly Evolving Structure of Water

Time-resolved infrared spectroscopy is shedding light on the dynamics of hydrogen bonding in liquid water.

**Andrei Tokmakoff**

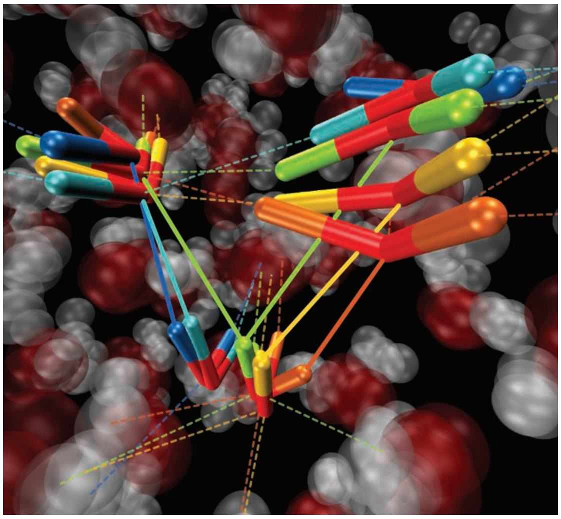
The molecular origins of the physical properties of water continue to puzzle scientists. Each tool provides only a limited perspective, revealing certain aspects of the hydrogen-bonding structure or of the ultrafast time scales over which the structure changes. Now, a new generation of time-resolved vibrational spectroscopies is providing detailed insights into how the structure of water evolves. The results raise questions about the nature of hydrogen bonding.

The structure of liquid water is generally conceived as a disordered network of molecules connected by hydrogen bonds (*1*). This structure fluctuates and reorganizes on time scales between 10 fs ($10^{-14}$ s) and 10 ps ($10^{-11}$ s). This hydrogen-bond dynamics is at the heart of the unique physical, chemical, and biological properties of water. Insights into its structural properties have come from x-ray and neutron-scattering experiments, which lack dynamical information; insights into its dynamics have been gained from ultrafast time-resolved experiments, which have lacked structural detail. The most detailed understanding of liquid water derives from molecular dynamics simulations, which commonly treat the liquid as rigid molecules with charges. Such simulations provide an atom-by-atom perspective on how hydrogen bonding changes with time, but their dynamics have never been properly tested against experiment.

Femtosecond infrared spectroscopy bridges the gap between these methods by providing a structure-sensitive probe of how the hydrogen-bond network in liquid water evolves. In these studies, hydrogen bonding is probed by monitoring the frequency of the O-H bond–stretching vibration, which decreases with increased strength of the hydrogen bond in which it participates. The newest method of two-dimensional infrared spectroscopy (2D IR) uses ultrafast infrared light pulses to track how the frequencies of different O-H bonds evolve with time.

However, spectroscopy cannot tell you everything. Simulations are important for providing the structural interpretation of the experiments, drawing on a theoretical description of how the O-H frequency is determined by hydrogen-bonding structure (*2*–*4*). This interpretation tool has initiated a feedback process in which the simulation describes how structural changes appear in the experiment, and the experiment provides the benchmark for the computer model.

Asbury *et al.* were the first to perform 2D IR experiments on water (*5*). By studying the isolated O-D vibration of dilute HDO in $H_2O$ (D is the $^2H$ isotope), they mapped the time scales over which a water molecule samples different hydrogen-bonding configurations. They observed dynamics on time scales of 48 fs, 400 fs, and 1.4 ps, and attributed the short times to fluctuations in the hydrogen bonds and the long times to hydrogen-bond breaking and forming. These results were qualitatively similar to simulations, but the time scale for hydrogen-bond breaking was nearly two times slower than for the widely used SPC/E and TIP4P water models. Fecko *et al.* made similar observations for HDO in $D_2O$ using the related technique of echo peak shift spectroscopy. In addition to 50-fs fluctuations,



**Switching a hydrogen bond.** In this 288-fs sequence taken from a classical simulation, structural fluctuations induce the switching of a hydrogen bond between the donor molecule (bottom) and an acceptor molecule (upper left) to a new acceptor (upper right). The hydrogen-bond connectivity is color coded, showing the rotation from the initial acceptor (blue) through the bifurcated state (green) to the approaching new acceptor (orange).

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