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The Cognitive Dynamics of Beliefs: The Effect of Information on Message Processing

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This study investigated the time course of belief change from univalent versus mixed-valence messages, both while the message was being received and after receipt while it was being considered. Hypotheses about the temporal patterns of belief change were tested with belief trajectories from S. E. McGreevy (1996), valid N *= 78, with an average number of time points per person = 5,267 (126.41 seconds) for the message-receipt phase and 2,467 (59.22 seconds) for the postmessage phase. Results showed that while receiving a message, beliefs changed according to the value and the order of presentation of information in the message. A greater number of positive belief changes were generated in response to a positive univalent message than to a mixed-valence message. In the postmessage phase, a greater oscillatory pattern of belief change was found for a mixed-valence message than for a univalent message. Theoretical and methodological implications of these findings are discussed.*

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> In an ideal world, with no constraints on data collection, the observation of sets of variables over time would provide all the information necessary for laying out the system of causal relations which tied the variables together. (Coleman, 1968, p. 475)

Belief change refers to the difference between an initial belief position before receipt of a new message and the subsequent final belief position after processing the message. During message processing, a belief moves from its initial position to its new equilibrium position. But how does the belief change? Does the belief position steadily approach its final position or does it drastically change to the final position at a specific time point, for example, after the message information has been cognitively integrated with the prior constellation of beliefs? These are questions about the time course of belief change.

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As the Coleman (1968) epigraph suggests, the observation of the changes of beliefs over time should provide all the information about the causal relations between message variables and belief change. For example, the effect of order of message presentation on belief change (e.g., primacy vs. recency; Hovland et al., 1957; Stone, 1969) can be observed merely by looking at the final belief position; however, the process by which the belief changes can be more clearly revealed by its over-time trajectory, in which the way that the belief changes in response to each piece of message information and in response to cognitive processing may be assessed. Despite its importance, the time course of belief change is little known.

Previous studies about the time course of belief change (Anderson & Farkas, 1973; Brehm & Wicklund, 1970; Fink, Kaplowitz, & Hubbard, 2002; Kaplowitz, Fink, & Bauer, 1983; McGreevy, 1996; Tesser, 1978; Vallacher, Nowak, & Kaufman, 1994; Walster, 1964; Wang, 1993) have provided only limited information about the time course of belief change. This limitation is due to either the insufficient number of over-time measurements or the shortcomings of the analytic methods employed (see Arundale, 1980). In addition, most of previous studies of belief dynamics have focused on patterns of belief change after message receipt. In other words, belief change that may occur during the time interval during which a message is seen or heard was not examined. However, belief change may also occur during this period. The current study investigates belief trajectories during the message-receipt phase and during the postmessage phase. Belief trajectories during the message-receipt phase not only indicate the overall effect that the message has on belief change but also the effect that specific pieces of information within the message have. Belief trajectories during the postmessage phase provide information about cognitive activities while making decisions and while adopting a new belief, maintaining one's initial belief, or resisting changing one's belief. In the present study, the patterns of belief change during the message-receipt phase are predicted based on information integration theory (Anderson, 1971), and the patterns of belief change during the postmessage phase are predicted based on the spatial-linkage model of cognitive forces (Kaplowitz et al., 1983).

Belief change during message receipt

Information integration theory (Anderson, 1971; Anderson & Farkas, 1973) provides insight into belief change during the message-receipt phase. Information integration theory states that (a) the effect of each piece of information is captured by two parameters, its scale value (valence) and its weight (importance) and (b) the amount of belief change in response to multiple pieces of information can be expressed as a weighted sum of the valence of the pieces of information:

$$P_\tau = \frac{w_0 s_0 + \sum_{i=1}^{\tau} w_i s_i}{w_0 + \sum_{i=1}^{\tau} w_i}, \tag{1}$$

where P_τ is the belief position after processing τ pieces of information, w_i and s_i represent the weight and scale values of a given piece of information, w_0 and s_0 are the weight and scale value of the initial belief, and the other *w*s and *s*s represent the weights and scale values of the new information.

Equation (1) can be used to predict belief positions over time as multiple pieces of information are being processed. Assuming that one piece of information is processed at a time, the belief position at a certain time point can be predicted by the weighted sum of the value of the pieces of information previously processed.[1] Because the message recipient is assumed to cognize (hear and read) information in a message in the order in which the information is presented, belief trajectories in the message-receipt phase can be predicted by the value, weight, and order of the pieces of information in the message. When the weight of the information is unknown but can be assumed to be nonzero, the effect of the information can be predicted (at least to some extent) by the order and the value of the information. We propose that information integration during the message-receipt phase may be adequately modeled using the value and the order of the message information, with the weight of the various pieces of information assumed to be equal.

Some messages contain only positive or only negative information about an object, whereas some messages contain both positive and negative information; the former messages are *univalent*, and the latter messages are *mixed valence*. Equation (1) suggests that the belief trajectories of univalent and mixed-valence messages differ. Suppose an individual has never been exposed to a specific belief object (e.g., a new political candidate); the individual is expected to have a relatively neutral belief toward that object initially. If the individual is presented with several pieces of positive information about the object, Equation (1) suggests that the pattern of belief change will be unidirectional: The belief trajectory is expected to consist of several discrete positive movements. On the other hand, if the recipient is presented with several pieces of negative information about the object that are followed by several pieces of positive information about the object (a mixed-valence message), the belief trajectory is expected to consist of several discrete negative movements followed by several discrete positive movements, resulting in a *U*-shaped pattern. Therefore, regarding the differences in patterns of belief change during the message-receipt phase, the following hypothesis is proposed:

H1: Belief trajectories during the message-receipt phase reflect the value and the order of the pieces of information in the message. As a result (a) a unidirectional (monotonic) belief trajectory occurs for a univalent message and (b) a *U*-shaped belief trajectory occurs for a mixed-valence message in which several pieces of negative information are followed by several pieces of positive information.

While receiving messages, a recipient may undergo several belief changes. According to information integration theory, the number of positive and number of negative pieces of information in the message are the primary factors determining the number of positive and negative belief changes during message receipt. In response to positively univalent messages, the message recipient is expected to have predominantly positive belief change during message receipt; if responding to mixed-valence messages with equal numbers of positive and negative pieces of information about a belief object, the number of positive belief changes is expected to be close to the number of negative belief changes. The following hypothesis is proposed:

H2: During the message-receipt phase, the number of positive belief changes is greater than the number of negative belief changes for positively univalent messages; however, the number of positive belief changes is about equal to the number of the negative belief changes for mixed-valence messages with relatively equal numbers of positive and negative pieces of information.

Belief change during the postmessage phase

McGuire (1960) suggested that upon receipt of a message, a belief is more likely to continue to change for some time until it settles down to a new stable position. Several studies have found that belief change continues for a time without new external information (Brehm & Wicklund, 1970; Chung, Fink, & Kaplowitz, in press; Fink et al., 2002; Gilbert, Krull, & Malone, 1990; Kaplowitz et al., 1983; McGreevy, 1996; Poole & Hunter, 1979; Tesser, 1978; Vallacher et al., 1994; Walster, 1964; Wang, 1993).

The pattern of belief change after message receipt may differ from the pattern found in the message-receipt phase. During the message-receipt phase, information in the message is salient because the information is new (i.e., the recipient just learned that it was part of the message) and recent; belief change is mostly affected by these new external pieces of information (see Note 1 for our assumption regarding the possible effect of cognitive responses during message receipt). However, once the message is comprehended, cognitive responses may be generated that are more salient than the information in the message. Based on Greenwald and Albert's (1968) finding that the persuasiveness of self-generated arguments is greater than those from external messages, Kaplowitz, Fink, Armstrong, and Bauer (1986) posited that self-generated arguments have more weight than external arguments; this increased effectiveness of self-generated arguments should be more likely when the message source is no longer salient, which should be after message receipt. Thus, belief change during the postmessage phase should be governed by self-generated cognitive responses as well as the intrinsic dynamics of the cognitive system (Chung et al., in press; Kaplowitz et al., 1983; Vallacher et al., 1994). The spatial-linkage model of cognitive forces (Kaplowitz et al., 1983) provides a theoretical framework for the intrinsic dynamics of the cognitive system and thus for patterns of belief change during the postmessage phase.

A spatial-linkage model of cognitive forces

Kaplowitz et al.'s (1983) spatial-linkage model of cognitive forces is explicitly aimed at describing and explaining belief change during judgment. Kaplowitz et al. (1983) used a physical metaphor for belief change and mathematically derived belief change trajectories. The model predicts several dynamic aspects of belief change during judgment, including an oscillatory pattern.

The model is built on four metaphors for belief systems. First, like an object in a physical system, a concept in a cognitive system is considered to have both location and mass in a cognitive space. Belief change is equivalent to the motion of a concept in the cognitive space (Fink et al., 2002; Kaplowitz et al., 1983; Woelfel & Fink, 1980). Second, the motion of a concept is assumed to be governed by Newton's laws (Kaplowitz et al., 1983). Third, the model assumes that concepts in a cognitive space may be linked with each other and that the linkages are spring like rather than brace like (i.e., the linkages are not of fixed length; see Dinauer & Fink, 2005; Fink & Kaplowitz, 1993; Fink et al., 2002; Fink, Monahan, & Kaplowitz, 1989; Kaplowitz & Fink, 1982, 1988, 1992, 1996; Kaplowitz et al., 1983; Woelfel & Fink, 1980). Like the operation of a mechanical spring, the model assumes that when a concept is moving, two opposing forces operate: a force moving the concept away from its initial location and a force restoring the initial position. The formal model includes a coefficient that represents the strength (i.e., the restoring force) of the spring (see Ingard & Kraushaar, 1960). As a result of these opposing forces, concepts disturbed by new information are likely to oscillate before reaching a new equilibrium position. Finally, the spring-like linkage model also assumes the damping of cognitive motion: Just as the motion of a spring dies out, when beliefs oscillate, such cognitive oscillations are also expected to die out.

With Newton's laws of force and motion and the assumption of cognitive damping, change in accordance with the following differential equation (Kaplowitz & Fink, 1982, p. 374; see also Woelfel & Fink, 1980, p. 159) is expected:

$$m\frac{\mathrm{d}^2P^*}{\mathrm{d}t^2} + c\frac{\mathrm{d}P^*}{\mathrm{d}t} + KP^* = 0, \tag{2}$$

where P^* is the distance of a concept from its equilibrium location, t is time, K is the net restoring coefficient on the concept, m is the mass of the concept, and c is the damping coefficient. Psychologically, m is the degree to which the belief resists change and c represents those forces that prevent continued thinking about the belief and thus prevent the belief from continuing to change at a constant rate indefinitely.

The solution to Equation (2) leads to three distinct results depending on the relation of m and c. For the critically damped (if $c^2 = 4Km$) and overdamped (if $c^2 > 4Km$) solutions (Boyce & DiPrima, 1997), the belief object moves to its new equilibrium position without oscillation. On the other hand, the underdamped solution (if $c^2 < 4Km$) is:

$$P_t = \mathrm{e}^{rt}(a_1 \sin \omega t + a_2 \cos \omega t), \tag{3}$$

where a_1 and a_2 reflect initial conditions, $r = -\frac{c}{2m}$, and $\omega = \frac{\sqrt{4km - c^2}}{2m}$ (Boyce & DiPrima, 1997; Kaplowitz & Fink, 1982). This case results in oscillation with damping, in which the belief concept oscillates around its equilibrium value with a period $= \frac{2\pi}{\omega}$, where π is the transcendental number equal to the ratio of a circle's circumference to its diameter. Figure 1, which shows oscillation with damping, represents Equation (3) when $c > 0$. If we assume that cognitive systems have a damping force just as mechanical systems have friction, then $c > 0$ and $r < 0$. In this case, the cognitive motion will be oscillation with damping.

If we assume Equation (3) is correct in that the concepts in a cognitive system have spring-like linkages, the trajectory of beliefs during the postmessage phase is most likely to be oscillation with damping. Oscillation with damping suggests that during the postmessage phase, the direction of belief change alternates repeatedly and the absolute amount of belief change in each direction decreases as the belief approaches equilibrium. However, the oscillatory pattern of belief change is expected to be greater for mixed-valence messages than for univalent messages. According to cognitive dissonance research (Festinger, 1957; Festinger & Walster, 1964; Walster, 1964), individuals are disposed to have at least some belief reversals after decision making: After choosing one desired alternative over another, individuals initially experience regret, which occurs because information that is incongruent with the decision (i.e., the negative aspects of the chosen alternative and the positive aspects of the unchosen alternative) becomes salient. As a result, after the initial decision, the favorability of the chosen alternative temporarily decreases but the favorability of the unchosen alternative increases. This postdecisional regret is reduced by increasing the favorability of the initially chosen alternative and by decreasing the favorability of the initially rejected alternative; this change appears as an oscillation in the belief trajectory. The spatial-linkage model suggests that this kind of belief reversal continues until the belief reaches equilibrium.

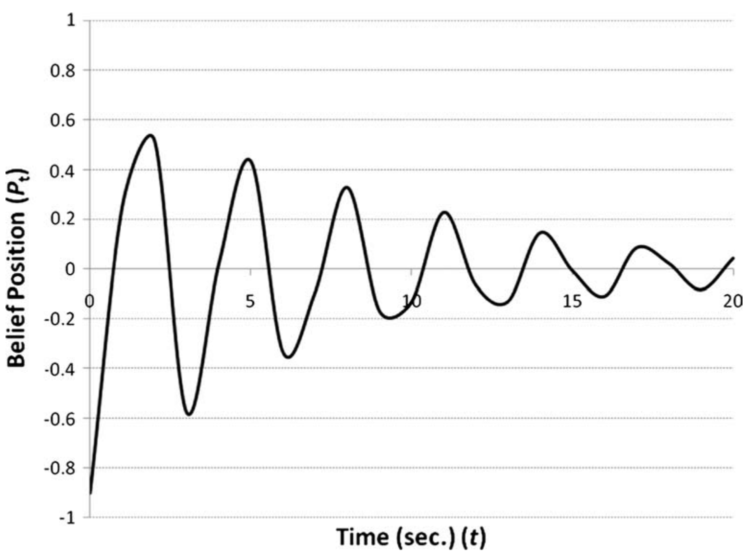

Figure 1 An example of an underdamped oscillatory trajectory of beliefs. $P_t = e^{rt}(a_1 \sin \omega t + a_2 \cos \omega t)$; $r = -0.125$; $a_1 = -0.100$; $a_2 = -0.900$; $\omega = 2.000$.

Comparing mixed-valence messages (e.g., messages describing two candidates with similar qualifications) with univalent messages (e.g., messages describing one candidate with strong qualifications and another candidate with weak qualifications), after an individual makes an initial decision (e.g., choosing one candidate over the other), information that is incongruent with the decision is more available for mixed-valence messages than for univalent messages. For mixed-valence messages, individuals are more likely to be exposed to incongruent information, which becomes salient after the initial decision. As a result, individuals who receive a mixed-valence message are likely to experience postdecisional regret and subsequent dissonance reduction. According to the spatial-linkage model, belief reversal continues until it dies out, which suggests an oscillatory pattern of belief change. Therefore, more oscillation of belief change should occur for mixed-valence messages than for univalent messages. Thus, the following hypothesis:

H3: During the postmessage phase, the degree of oscillatory belief change is greater for mixed-valence messages than for univalent messages.

The damping pattern of belief change can also be expressed in terms of the belief trajectory. If there is a damping pattern of belief change during judgment, the absolute amount of belief change will decrease over time. To test the damping pattern of belief change during judgment, the following hypothesis is proposed:

H4: During the postmessage phase, the absolute amount of a belief change at any given time is smaller than the absolute amount of the preceding belief change.

Differently valenced messages (i.e., univalent vs. mixed-valence messages) are expected to generate different cognitive responses (Greenwald, 1968; Petty, Ostrom, & Brock, 1981). Assuming that self-generated cognitive responses are reflected in belief trajectories during the postmessage phase, a positively univalent message is expected to generate more positive cognitive responses than negative cognitive responses. On the other hand, a mixed-valence message with a relatively equal number of positive and negative evaluations is expected to generate about an equal number of positive and negative cognitive responses. These cognitive responses generate belief change even if that change is only temporary. Therefore:

H5: During the postmessage phase, the number of positive belief changes is greater than the number of negative belief changes induced by positively univalent messages, whereas the number of positive belief changes is about equal to the number of the negative belief changes induced by mixed-valence messages with about an equal number of positive and negative pieces of information.

Belief change during the message-receipt phase and the postmessage phase

How many times does the belief change during the message-receipt phase and the postmessage phase? What is the relationship between the message valence and the number of belief changes? Because information in the message is salient during the message-receipt phase, the number of pieces of information in the message is likely to be a dominant factor determining the number of belief changes during that phase regardless of message valence. Therefore, when the number of pieces of information between univalent messages and mixed-valence message is about equal, the number of belief changes for these two message types is expected to be about equal during the message-receipt phase.

On the other hand, during the postmessage phase, self-generated cognitive responses are more salient (Greenwald & Albert, 1968; Kaplowitz et al., 1986), and the number of cognitive responses is a function of decision difficulty when other factors are controlled: There will be more cognitive responses for a difficult decision than for an easy decision, especially when the decision is between just two alternatives. When mixed-valence messages are presented, the decision is more difficult than when univalent messages are presented. Therefore, during the postmessage phase, mixed-valence messages are expected to generate more cognitive responses and more changes in belief than univalent messages:

> H6: (a) During the message-receipt phase, if the number of pieces of information in a univalent message and in a mixed-valence message is about equal, the number of belief changes induced by these two message types is about equal; (b) during the postmessage phase, the number of belief changes induced by mixed-valence messages is greater than the number induced by univalent messages.

Method

Overview and participants

To test the proposed hypotheses, data from McGreevy (1996) were analyzed. In her main study, participants were given information about two candidates for college admission and asked to choose between them. Participants' evaluations of the candidates were measured approximately every 24 ms using a computer mouse technique, both while participants were reading the experimental messages (the message-receipt phase) and after they finished reading (the postmessage phase). Participants received either a univalent message or a mixed-valence message about these two candidates and were distracted (by noise) or not distracted. This study is a between-participant factorial design with repeated measures over time, a 2 (message type: univalent vs. mixed-valence) $\times$ 2 (distraction: distraction vs. no distraction) experiment. The experiment was conducted in a laboratory with one participant per session.

Seventy-eight undergraduate students completed the experiment. A sample size of 78 provided statistical power of .99 to detect a critical effect size (Δ) of 0.50 in a 2 $\times$ 2 analysis of variance (ANOVA) design (see Kraemer & Thiemann, 1987, p. 42, for the definition of Δ). Participants were between 19 and 22 years old and they received extra credit from their course instructor for participating in the study.

Procedure

Pilot studies

To develop the messages about candidates for college admission, a series of pilot studies were conducted. To determine the characteristics of individuals who were expected to be successful or unsuccessful in college, participants (N = 21) were presented with a list of characteristics and asked to indicate the values of the characteristics as indicators of success or failure in college. The values of the characteristics were measured on a scale in which 0 indicated the highest probability of failure in college and 10 indicated the highest probability of success in college. Based on this pilot study, different characteristics associated with college success that were not significantly different from each other were selected. In addition, characteristics associated with failure in college that were significantly different from those characteristics representing success in college were selected. Messages about candidates were created with these success and failure characteristics (see Table 1).

Main study

Participants entered the experimental laboratory and were told that the researcher was conducting a study on attitudes. Participants completed a consent form. Participants were then told that their task involved making a decision between two individuals for some outcome and that their responses would be recorded on a computer. Then, the participants were trained in the use of the computer mouse to represent their thinking. First, they were asked to recall actual decisions that they had recently made. Speaking out loud, the participants reported the sequence of thoughts that they went through in coming to their decision. Participants were instructed to move the computer mouse between two endpoints on the computer screen while talking and thinking. Once participants knew how to complete the decision task using the computer mouse, they received written instructions for the study. The instructions stated that the admissions office at the university was considering adding a student to its admissions committee and wanted to get some input from current university students about admission decisions and how to choose between candidates for admission. The instructions stated:

> Below is information about two out-of-state candidates for admission into [the university]. We will refer to these candidates as **Candidate 1** and **Candidate 2**. An admissions decision must be made on the basis of each candidate's relative grade point averages and SAT scores as well as on the information provided in each candidate's application. Below is summary data about each candidate put together by the admissions office.
>
> Please take some time and decide which candidate you would be willing to accept into college. You **must** choose **one** of the candidates. Your decision process will be recorded on the computer. After you have decided which candidate is more suitable to college, you will be asked to fill out

Table 1 Value of Characteristics for Success in College (McGreevy, 1996, Pilot Data 1C)

Characteristic	*M*	*SD*
Candidate 1 in the mixed-valence message condition		
Intelligent (impressive academic record and SAT) (2)	8.75	1.07
Debate team (4)	7.57	1.43
Student government (6)	7.71	1.38
Captain of a sports team (8)	7.05	1.32
Hardworking (10)	9.05	0.92
Determined (10)	8.48	1.33
Volunteers for community service (12) (15)	7.24	1.14
Disciplined (16)	8.38	1.24
Candidate 2 in mixed-valence and univalent message conditions		
Intelligent (2)	8.75	1.07
Captain of a sports team (4)	7.05	1.32
Debate team (4)	7.57	1.43
Student government (6)	7.71	1.38
Volunteers for community service (10) (11)	7.24	1.14
Confident (14)	8.19	1.03
Motivated (14)	8.86	0.85
Responsible (14)	8.90	1.22
Disciplined (16)	8.38	1.24
Candidate 1 in the univalent-message condition		
Average GPA and SAT (2)	Not measured	
Enjoys skiing (4)	5.19	1.08
Enjoys snowboarding (4)	4.90	1.18
Enjoys skateboarding (5)	4.90	1.34
Plays tennis (7)	5.48	0.98
Enjoys mountain bikes (7)	5.71	0.90
Shy (8)	4.33	1.24
Artistic (8)	5.57	1.08
Plays electric guitar (9)	5.33	0.97
Plays acoustic guitars (9)	5.48	0.98
In rock band (10)	4.14	1.35
Has three part-time jobs (12)	4.57	1.69

Note: $N = 21$. The data were from Table 3 and Table 4 in McGreevy (1996). Likert-type scales with 11 points were used, in which 0 indicated the highest probability of failure in college and 10 indicated the highest probability of success in college. The number in parentheses represents the ordinal number of the sentence in which the characteristic was described. The value of the first item for Candidate 1 in the univalent-message condition, average GPA, and SAT, was assigned 5.00, the neutral value, because it was not measured in the pilot study. GPA = grade point average.

a questionnaire. Please record your choice in the space provided and answer the remaining questions in the questionnaire. Information from the questionnaires will be summarized and forwarded to the admissions office at the university.

After reading these instructions, the participants received messages about the two candidates. The messages had two parts: The first part described characteristics of Candidate 1 and the second part described the characteristics of Candidate 2 (see Table 1). Each participant was asked to indicate his or her belief on a computer screen that had a 100-point scale by using a computer mouse both while receiving (i.e., reading) the message and after receiving the message while thinking about the decision. Participants' beliefs were measured approximately every 24 ms both while participants were reading the experimental messages (the message-receipt phase) and after they finished reading (the postmessage phase). Participants indicated the end of the message-receipt phase by clicking a button on the computer mouse. When participants reached their final decision, they also clicked a computer mouse button to indicate the end of their judgment.

Participants' movement of the computer mouse generated individual-belief trajectories (see Figure 2). The computer mouse technique has been discussed in Fink and Kaplowitz (1993), Kaplowitz and Fink (1996), Wang (1993), and Fink et al. (2002). Vallacher et al. (1994) used a similar computer mouse technique to obtain belief trajectories. When participants followed the instructions correctly, two distinctive mouse clicks were expected, one to indicate the end of the message-receipt phase and one to indicate that the final judgment was made. Originally, 102 students participated in the study. However, some trajectories contain more than two clicks (19%) or fewer than two clicks (12%). After careful examination of trajectories, 24 cases out of the 102 were dropped due to the indistinctiveness of the two phases. Seventy-eight cases were used for all analyses except those dealing with induction checks.

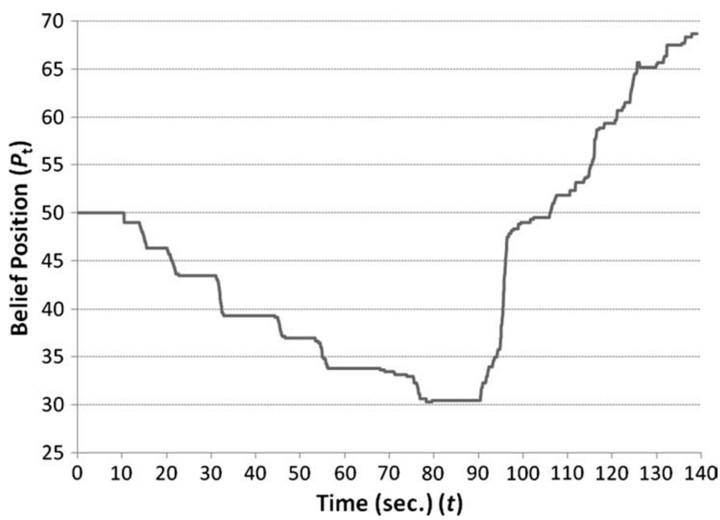

Figure 2 A belief trajectory during the message-receipt phase in the mixed-valence message and no-distraction condition (Participant No. 65; 1–139.08 seconds; from McGreevy, [1996]).

Independent variables

Two independent variables were manipulated: message type (univalent message vs. mixed-valence message) and distraction (distraction present vs. distraction absent).

Message-type manipulation.

Message type was manipulated by varying the valence of information about two candidates. In the mixed-valence message condition, participants received several pieces of positive information about Candidate 1 (i.e., characteristics that are indicative of success in college) and then received several pieces of positive information about Candidate 2. Because the decision about whom to recommend for college admission was dichotomous, positive information about one candidate had negative implications for the evaluation of the other candidate. Focusing on Candidate 2, participants in this mixed-valence condition received a mixed-valence message; several pieces of negative information were followed by several pieces of positive information about the candidate. On the other hand, in the univalent-message condition, participants received several pieces of negative information about Candidate 1 (i.e., characteristics that do not fit with success in college) and then received several pieces of positive information about Candidate 2; both the first part of the message and the second part of the message provided positive (i.e., not unfavorable) information about Candidate 2.

Distraction manipulation

Distraction was manipulated by varying environmental noise. In the distraction condition, participants were placed in a room in which feedback sound from a camera and a VCR hookup was heard constantly (see McGreevy, 1996, p. 116). In the no-distraction condition, there was no such noise. In the current study, the effect of distraction on belief change was not discussed because no hypothesis was proposed for distraction. However, distraction was included in the hypothesis-testing analyses because it is one of the two manipulated independent variables and including it should reduce within-cell variability.

Dependent variables

Belief position

The relative suitability of the candidates for college admission was measured on the computer screen on a scale in which 0 indicated complete favorability for Candidate 1 and 100 indicated complete favorability for Candidate 2. Thus, higher values on the scale indicated greater favorability for Candidate 2. This scale constrained favorability to be unidimensional. In other words, favorability about Candidate 1 and favorability about Candidate 2 were constrained to be perfectly negatively linearly related.

Belief trajectories obtained by the computer mouse technique provided thousands of belief positions for each individual. Among these thousands of positions, some key positions were extracted to be analyzed. Most belief trajectories showed step-like movement: A belief moves to a scale position and then stays at that position for a period before moving to another position. These belief trajectories showed repetitions of a move and a stay (see Figure 2). This pattern has been found in most studies using the computer mouse technique (see Fink & Kaplowitz, 1993; Fink et al., 2002; McGreevy, 1996; Vallacher et al., 1994; Wang, 1993).

Because a belief trajectory consists of sequential moves-and-stays, belief trajectories can be partitioned into multiple local (i.e., single move-and-stay) movements. A *stay* is a set of consecutive belief positions that do not have a significant change within a certain period of time (see below for coding procedures). A *move* is a set of consecutive positions between two stays. A local movement has one significant belief position, which is the position of the stay. Because the position of a local movement is different from positions of adjacent local movements, a local movement represents a belief change during judgment. Among the thousands of belief positions, positions for local movements were extracted as key positions of belief trajectories for both the message-receipt phase and the postmessage phase. This procedure was used to eliminate changes that might reflect accidental movements such as those due to overshooting or undershooting a position or those due to an unsteady hand movement.

Selection of belief positions

Belief trajectories had different numbers of local movements and different numbers of key positions. To analyze patterns of belief trajectories, several key positions were selected based on ordinal time points (i.e., the relative time in the belief trajectory). Five ordinal time points for the message-receipt phase and three ordinal time points for the postmessage phase were selected from each trajectory. For the message-receipt phase, the time point after the first local movement, the starting point of the second stay, was selected (ordinal time point 1). In addition, the starting point of the 25th percentile rank of the stays of the message-receipt phase, the 1st quartile time point, was selected (ordinal time point 2). For example, if a trajectory had 12 stays in total during the message-receipt phase, the starting point of the 3rd stay is the 1st quartile point. The starting point of the 50th percentile rank of the stays during the message-receipt phase (ordinal time point 3), the starting point of the 75th percentile rank of the stays of the message-receipt phase (ordinal time point 4), and the time point for the final stay of the message-receipt phase (ordinal time point 5) were also selected. Positions at those five time points are expected to show overall patterns of belief change during the message-receipt phase, including whether the trajectories are *U*-shaped or unidirectional.

For the postmessage phase, the time point after the first local movement of the postmessage phase (ordinal time point 6), the starting point of the 50th percentile rank of the postmessage phase (ordinal time point 7), and the time point for the final stay of the postmessage phase (ordinal time point 8) were selected.

Degree of oscillatory belief change

Belief trajectories may show different degrees of oscillatory belief change. Except for the first local movement, local movements can be divided into two cases: (a) the direction of a given movement is the same as the preceding one (no change in direction) or (b) the direction of a given movement is in the opposite direction to the preceding one (change in direction). The percentage of movements with changes in direction indicates the degree of the oscillatory pattern in the belief trajectories. This percentage was obtained by dividing the number of changes in direction by the total number of local movements after the first local movement.

Positivity of movements
Belief trajectories differ in terms of the proportion of positive belief movements to negative belief movements. To assess the extent to which positive belief movements exceeded negative belief movements, the following formula was used:

$$\text{Positivity}_{\text{movements}} = \ln(p + 1) - \ln(q + 1), \tag{4}$$

where ln is the natural logarithm, p is the number of positive movements, and q is the number of negative movements. If the number of positive movements is equal to the number of negative movements, the positivity of the movements will be 0. A positive value of $\text{Positivity}_{\text{movements}}$ indicates a greater number of positive movements than negative movements. The above formula has an advantage compared to a simple ratio or difference of the number of positive to negative movements because it is a statistic that is more normally distributed than the ratio or difference and therefore is better able to meet the statistical assumptions of the general linear model (see Bauer & Fink, 1983).

Number of movements
The number of local movements was the indicator of the number of belief changes. The number of local movements in both phases was transformed before the analysis to meet the distributional assumptions required of the analyses that were performed (Bauer & Fink, 1983; Hanushek & Jackson, 1977). The original variable was transformed by taking its square root. Before the transformation, the number of movements in the message-receipt phase was not significantly skewed (skewness = 0.46, *ns*), but the number of movements in the postmessage phase was significantly skewed (skewness = 1.13, $p < .01$). After the transformation, the skewness of the variable was −0.44, *ns*, for the message-receipt phase and 0.53, *ns*, for the postmessage phase.

Data coding and analysis
From each trajectory, positions for local movements were extracted using a computer program that was written for this specific purpose. The duration of a stay in a trajectory varies depending on two constraints: (a) the amount of belief position difference (on the y-axis) that is considered a change in belief and (b) the amount of time (on the x-axis) that constitutes a stay, which will differentiate a stay from temporary stops during a move. As mentioned above, this procedure is a way of eliminating changes that represent small movements that may be unintended.

Tests were conducted to find the most appropriate values for the maximum position difference and the minimum stay length. We selected 1 for the maximum position difference (on the scale of 0–100) and 2 seconds for the minimum stay length; see Chung (2004) for the procedures used to determine these values. Using these values, positions of local movements in trajectories for both the message-receipt phase and the postmessage phase were extracted.

In all the analyses below, the alpha level was set at .05, two-tailed.

Results

Manipulation checks

Message type

For both the univalent-message condition and the mixed-valence message condition, the message about Candidate 2 was the same. Candidate 1 was described as having characteristics that were associated with success in college in the mixed-valence message condition and as having characteristics that were associated with failure in college in the univalent-message condition. To test the effectiveness of the manipulation of message type, participants were asked to indicate how suitable Candidate 1 was for college. For this measure, a magnitude scale was used in which 0 indicated not suitable at all, 100 indicated moderately suitable, and any number greater than 100 indicated a greater than moderate level of suitability. A magnitude scale was also used for the manipulation checks of message type and distraction. Prior to analysis, these magnitude-scale variables were transformed logarithmically to reduce skewness.

As expected, Candidate 1 was perceived as more suitable for college in the mixed-valence message condition, $M = 6.17$, $SD = 1.28$, than in the univalent-message condition, $M = 4.48$, $SD = 1.20$, $F(1, 97) = 46.14$, partial $\eta^2 = .32$, $p < .001$.[2] Participants were also asked to indicate how different the two candidates were. As expected, the perceived difference was found to be greater in the univalent-message condition, $M = 6.11$, $SD = 1.29$, than in the mixed-valence message condition, $M = 4.06$, $SD = 1.76$, $F(1, 97) = 44.53$, partial $\eta^2 = .31$, $p < .001$.

The mixed-valence message was also expected to result in a more difficult decision than the univalent message. Perceived decision difficulty was measured with two questions: (a) the personal difficulty of the decision and (b) the perceived difficulty of the decision for a typical person. As expected, personal difficulty was greater in the mixed-valence message condition, $M = 5.50$, $SD = 1.19$, than in the univalent-message condition, $M = 4.02$, $SD = 1.25$, $F(1, 97) = 36.10$, $p < .001$, partial $\eta^2 = .27$. Perceived difficulty for a typical person was also greater in the mixed-valence message condition, $M = 5.75$, $SD = 1.20$, than in the univalent-message condition, $M = 4.31$, $SD = 1.25$, $F(1, 97) = 36.12$, $p < .001$, partial $\eta^2 = .27$.

Belief change during message receipt

Duration of the message-receipt phase

The average duration of the message-receipt phase was 126.41 seconds ($SD = 33.72$ seconds; 5,267 time points for which data were collected). The average time for the message-receipt phase was 133.34 seconds ($SD = 34.09$ seconds, $n = 41$) in the mixed-valence message condition and 118.60 seconds ($SD = 33.72$ seconds, $n = 37$) in the univalent-message condition. The difference in the average time for the message-receipt phase between the univalent and the mixed-valence message conditions was marginally significant, $F(1, 74) = 3.95$, $p < .10$, partial $\eta^2 = .05$.

Patterns of belief trajectories

H1 proposes that belief trajectories during the message-receipt phase can be predicted by the value and the order of the pieces of information in the message (i.e., by applying Equation (1)). To test H1, first, belief trajectories were predicted based on the value and the order of the pieces of information in the messages. In the present study, the weight of the individual characteristics of the two (alleged) candidates for college was not measured, but the value of those characteristics for success in college was (see Table 1). Because only the scale values of the pieces of information were known, and because the initial beliefs about the candidates were neutral, belief position at a certain time point is predicted by the sum of the valence of the pieces of information previously processed.

Figure 3 shows the belief trajectory predicted by the value and the order of the pieces of information in the message for the message-receipt phase. To predict belief change, the values of the pieces of information had 5.00 subtracted from them, making the values positive for positive characteristics and negative for negative characteristics. Then, the values of the pieces of information that appeared in the

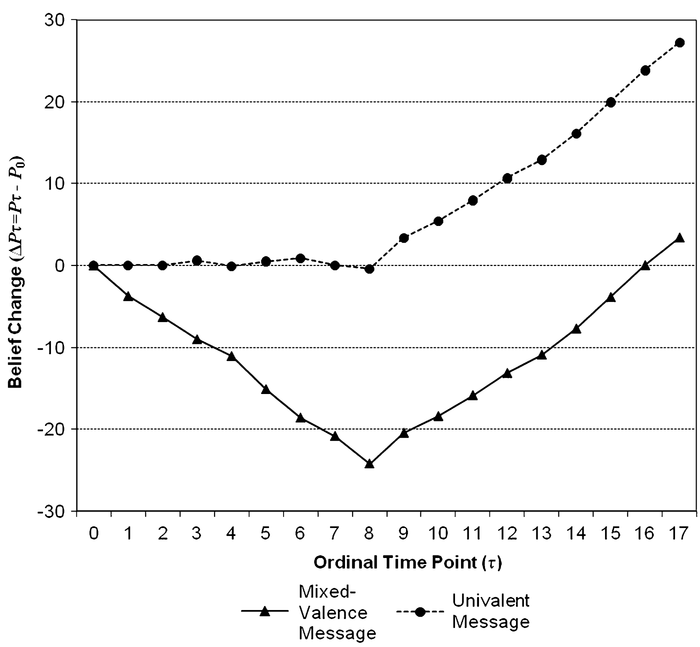

Figure 3 Predicted belief change from the initial position during the message-receipt phase.

same sentence were averaged. The value of the first item for Candidate 1 in the univalent-message condition, average grade point average and SAT, was assigned 5.00, the neutral value, because it was not measured in the pilot study. Figure 3, exhibiting the predicted trajectories, shows a *U*-shaped belief trajectory for the mixed-valence message. For the univalent message, the predicted belief position stays at the neutral point for the first half of the message (information about the Candidate 1) and subsequently increases.

The observed belief trajectories during the message-receipt phase are shown in Figure 4. The initial time point and five ordinal time points were used (see above description of the time points selected), and only cases with at least five key positions were used (N = 62). The initial position (50.00) was subtracted from the scores of subsequent movements. Thus, the dependent variable was the amount of belief change from the initial position. The overall observed belief trajectories in the message-receipt phase were found to be similar to the predicted patterns shown in

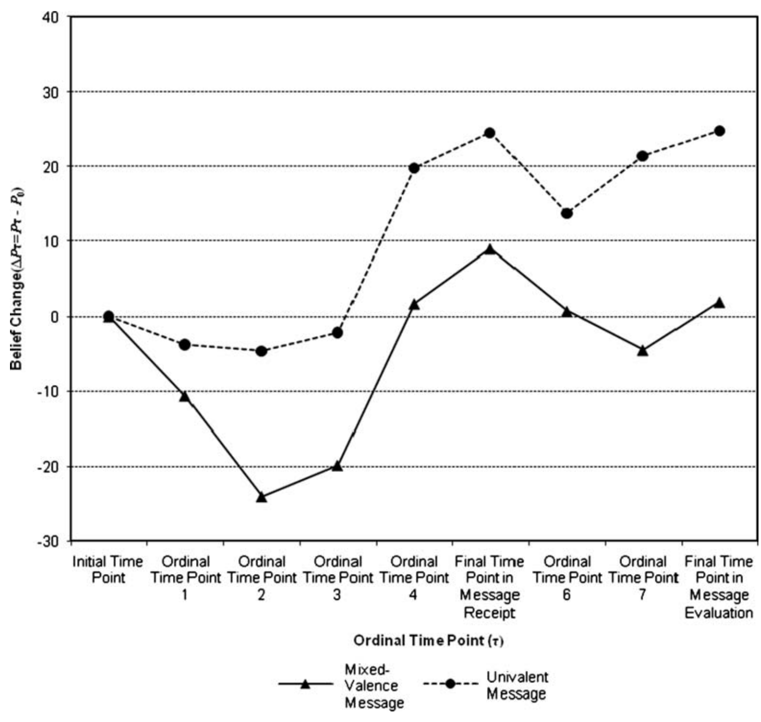

Figure 4 Belief change from the initial position for eight ordinal time points by message type in the message-receipt phase (N = 62) and in the postmessage phase (N = 52), from McGreevy (1996). Only cases that had at least five movements were used for the message-receipt phase and only cases that had at least three movements were used for the postmessage phase. Values are averages for each condition at each time point. Greater positive values of position change indicate greater favorability toward Candidate 2.

Figure 3: For the mixed-valence message condition, a U-shaped pattern for the belief trajectory was found; for the univalent-message condition, the amount of belief change was negative and absolutely less than -5.00 for the first half of the message-receipt period and then it increased.

To test H1, repeated-measures ANOVAs were conducted for the first half and for the second half of the message-receipt phase. As shown in Figure 3, for the first half of the message-receipt phase, a decrease of belief change was expected for the mixed-valence message condition but no effect of time on belief change was expected for the univalent-message condition. In the repeated-measures ANOVA for the first half of the message-receipt phase, the amount of belief change from the initial position was predicted by message type (as manipulated; univalent vs. mixed valence), distraction (also a manipulated variable with two levels), and ordinal time with four time points: initial point, ordinal time point 1, ordinal time point 2, and ordinal time point 3. Results showed ordinal time had a significant linear and quadratic effect on belief change: $F(1, 58) = 17.05$, $p < .01$, partial $\eta^2 = .23$, for the linear effect; $F(1, 58) = 7.06$, $p < .05$, partial $\eta^2 = .11$, for the quadratic effect. Message type also had a statistically significant effect on belief change, $F(1, 58) = 14.47$, $p < .01$, partial $\eta^2 = .20$. More importantly, a statistically significant interaction was found between ordinal time and message type, $F(1, 58) = 17.51$, $p < .01$, partial $\eta^2 = .23$.

To examine the different effects of ordinal time on belief change between the message conditions, a repeated-measures ANOVA without any manipulated independent variable was conducted separately for each message-valence condition. The repeated measure was ordinal time, and the dependent variable was the amount of belief change from the initial position. In the mixed-valence message condition, ordinal time had a statistically significant effect, $F(1, 28) = 32.00$, $p < .01$, partial $\eta^2 = .53$: The amount of belief change linearly decreased over time. On the other hand, in the univalent-message condition, ordinal time had no statistically significant effect on belief change, $F(1, 32) = 0.006$, *ns*.

Figure 3 suggests a linear increase of belief change for both types of messages for the second half of the message-receipt phase. A repeated-measures ANOVA was conducted for the second half of the message-receipt phase, in which the amount of belief change from the initial position was predicted by message type, distraction, and ordinal time with three time points: ordinal time point 3, ordinal time point 4, and ordinal time point 5. Results showed that the amount of belief change increased over time as a function of linear ordinal time, $F(1, 58) = 58.18$, $p < .01$, partial $\eta^2 = .50$, and as a function of quadratic ordinal time, $F(1, 58) = 10.85$, $p < .01$, partial $\eta^2 = .16$. Message type had a statistically significant effect on belief change, $F(1, 58) = 14.47$, $p < .01$, partial $\eta^2 = .20$. However, there was no significant interaction between ordinal time and message type, $F(1, 58) = 0.32$, *ns*. For both message types, the amount of belief change increased over time during the second half of the message-receipt phase.

In summary, these results were consistent with H1. For the univalent-message condition, a flat trajectory followed by a monotonically increasing pattern was expected (H1a) and found. Belief trajectories in the mixed-valence message condition showed the expected (H1b) *U*-shaped pattern.

Positive and negative belief changes

H2 tests the relationship between message type (univalent vs. mixed valence) and the number of positive and negative belief changes during the message-receipt phase. To test H2, the dependent variable was the positivity of movements (see Equation (4)). Zero positivity means that the number of positive movements is equal to the number of negative movements. Results from an ANOVA in which the positivity of movements was predicted by message type and distraction showed that positivity of movements was greater in the univalent-message condition, $M = 0.45$, $SD = 0.61$, than in the mixed-valence message condition, $M = -0.02$, $SD = 0.63$, $F(1, 74) = 10.71$, $p < .01$, partial $\eta^2 = 13$. Message recipients generated more positive local movements than negative local movement in response to a positive univalent message as compared to a mixed-valence message. The mean positivity of movements in the mixed-valence message condition indicated that the number of positive and the number of negative movements was about equal. The mean positivity of movements in the univalent-message condition indicated that the number of positive movements was greater than the number of negative movements. These results showed that the number of local movements during message receipt reflected information in the message. H2 was supported.

Belief change during the postmessage phase

Duration of the postmessage phase

The average duration of the postmessage phase was 59.22 seconds ($SD = 57.06$ seconds; 2,467 time points for which data were collected). The average time for the postmessage phase was 81.43 seconds ($SD = 63.00$ seconds, $n = 41$) in the mixed-valence message condition and 34.61 seconds ($SD = 37.01$, $n = 37$) for the univalent-message condition. The difference in the average time for the postmessage phase between the univalent-message condition and the mixed-valence message condition was statistically significant, $F(1, 74) = 14.64$, $p < .01$, partial $\eta^2 = .16$.

Oscillation

H3 tests the oscillatory pattern of belief change during the postmessage phase. The percentage of changes in direction was used to measure the degree of oscillatory belief change. The overall average percentage of changes in direction was 24.92% ($SD = 28.57\%$). To test H3, an ANOVA was conducted in which the percentage of changes in direction was predicted by message type and distraction. The results showed that the percentage of changes in direction was significantly greater for the mixed-valence message condition, $M = 31.84\%$, $SD = 28.14\%$, than the univalent-message condition, $M = 17.26\%$, $SD = 27.42\%$, $F(1, 74) = 5.13$, $p < .05$, partial $\eta^2 = .07$. H3 was supported.

Damping pattern

H4 tests the damping pattern of belief change during the postmessage phase. A damping pattern can be assessed by examining whether the absolute amount of belief change by local movements decreases as the decision is approached. To test for a damping pattern of belief change, the absolute amounts of belief change at the last two movements were compared. Only cases that had at least two local movements were included for this analysis.

A repeated-measures ANOVA ($N = 54$) was conducted on the absolute amount of belief change from the previous belief by ordinal time, message type, and distraction. Ordinal time was a repeated measure and consisted of two time points, the local movement before the final local movement and the final local movement. The absolute amount of belief change was significantly greater for the final movement, $M = 34.87$, $SD = 27.55$, than for the penultimate movement, $M = 14.34$, $SD = 19.38$, $F(1, 50) = 37.12$, $p < .01$, partial $\eta^2 = .43$. This result indicated that the absolute amount of belief change increased rather than decreased at the end of judgment. Thus, based on the comparison of the penultimate and ultimate belief changes, the belief trajectories failed to exhibit a damping pattern. H4 was not supported.

Positive and negative belief changes

H5 tests the relationship between the message type and the number of positive and negative belief changes during the postmessage phase. To test H5, positivity of movements in the postmessage phase was obtained using Equation (4). Then, an ANOVA was conducted for positivity of movements by message type and distraction for the postmessage phase. Results showed that positivity of movements in the postmessage phase was greater for the univalent (positive) message than for the mixed-valence message, $F(1, 74) = 4.88$, $p < .05$, partial $\eta^2 = .13$. In the mixed-valence message condition, the number of positive movements was not much different than the number of negative movements (the mean positivity of movements = -0.05; $SD = 0.63$), whereas in the univalent (positive) message condition, the number of positive movements was greater than the number of negative movements (the mean positivity of movements = 0.31; $SD = 0.70$). This result suggested that individuals had more positive belief changes in response to a positively univalent message, whereas they had an approximately equal number of positive and negative belief changes during judgment in response to a mixed-valence message. Message type had the predicted effect on local movements during the postmessage phase. H5 was supported.

Belief changes during the message-receipt phase and the postmessage phase

Number of belief changes

H6 tests the relationship between the message type and the number of belief changes. In the univalent message, 21 discrete pieces of information were presented in total (12 characteristics for Candidate 1 and 9 characteristics for Candidate 2). In the mixed-valence message, 17 discrete pieces of information were presented in total (8 characteristics for Candidate 1 and 9 characteristics for Candidate 2). Thus, the number of pieces of information in these two conditions is approximately equal. Therefore, the number of local movements was expected to be about equal between the two conditions in the message-receipt phase. However, in the postmessage phase, a greater number of local movements was expected in the mixed-valence message condition than in the univalent-message condition because the decision in the mixed-valence message condition was more difficult.

A repeated-measures ANOVA was conducted to test the relationship between the message type and the number of local movements. Message type and distraction were the independent variables, the message-processing phase (message-receipt vs. postmessage phase) was the repeated measure, and the number of local movements was the dependent variable. Results showed a statistically significant main effect of the message-processing phase on the number of local movements, $F(1, 74) = 43.56$, $p < .01$, partial $\eta^2 = .37$ ($M = 3.16$, $SD = 1.08$, for the message-receipt phase; $M = 2.25$, $SD = 0.94$, for the postmessage phase) and a statistically significant interaction between the message-processing phase and the message type, $F(1, 74) = 11.49$, $p < .01$, partial $\eta^2 = .13$ (see Figure 5). To examine the interaction between phase and message type, an ANOVA was conducted on the number of local movements by message type and distraction in each phase. Results showed that message type had a statistically significant effect on the number of local movements during

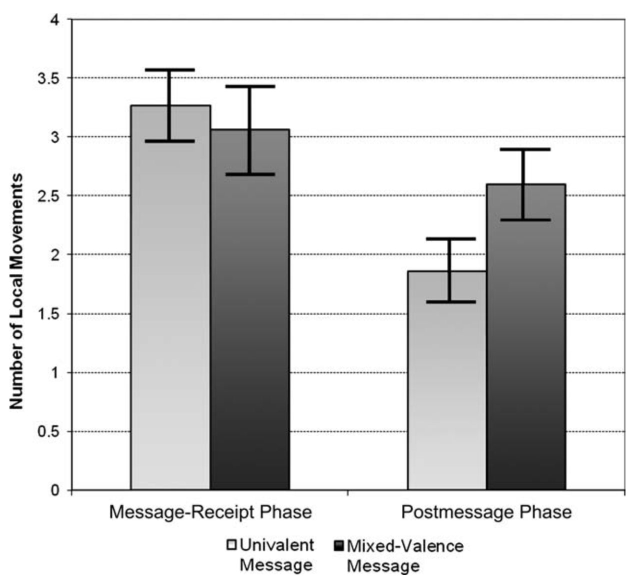

Figure 5 The number of local movements by message type and message-processing phase. The dependent variable was transformed by taking its square root to reduce the skewness of the variable. Error bars indicate 95% confidence intervals.

the postmessage phase, $F(1, 74) = 13.58$, $p < .01$, partial $\eta^2 = .16$ ($M = 2.60$, $SD = 0.94$, $n = 41$ for the mixed-valence message condition; $M = 1.86$, $SD = 0.79$, $n = 37$, for the univalent-message condition), but not during the message-receipt phase, $F(1, 74) = 0.79$, *ns*, partial $\eta^2 = .01$ ($M = 3.06$, $SD = 1.24$, $n = 41$, for the mixed-valence message condition; $M = 3.27$, $SD = 0.90$, $n = 37$, for the univalent-message condition). As predicted, the number of local movements did not differ between the univalent-message condition and the mixed-valence message condition during the message-receipt phase, but the number of local movements was greater in the mixed-valence message condition than the univalent-message condition during the post-message phase. H6 was supported.

Discussion

Information integration theory and belief change during the message-receipt phase

Information integration theory provides a well-known model that explains how beliefs are formed and modified as people receive new information (Eagly & Chaiken, 1993). The information integration model suggests that beliefs are modified through evaluation and integration of new pieces of information according to their valence and weight, and this model has been supported in many studies (see Anderson, 1971, for a review). Receiving and incorporating a new message by modifying one's beliefs occurs over time. Belief change as a result of evaluation and integration has not been investigated over time except by Anderson and Farkas (1973); however, their study had a limited number of pieces of information and measurements, making it not very useful for assessing the hypotheses advanced in the current study.

The present study tested information integration theory with belief trajectories. The observed trajectories showed that during the message-receipt phase, belief changes occur according to the value and order of presentation of information, and the final belief position at the end of the message-receipt phase is the sum of those belief changes. The findings suggest that evaluation and integration are two basic operations in belief change: During message receipt, the value of new information was cognitively integrated to determine the new belief position. These findings provide stronger evidence for information integration theory than any other previous studies in that (a) the theory was tested with a large number of pieces of information, (b) the theory was tested with time-series data, and (c) the effect of subparts of the messages (information molecules) on belief change was examined. Although we did not explicitly measure the weight of the pieces of information, the data did fit the model's predictions. Adding the appropriate weights would be expected to increase the predictive power of the information integration model.

The spatial-linkage model and belief change during the postmessage phase

Based on the spatial-linkage model of cognitive forces (Kaplowitz et al., 1983), this study predicted some dynamic aspects of belief change, specifically oscillation and damping, during the postmessage phase. As suggested by McGuire (1960) and predicted by the spatial-linkage model, beliefs were found to continue to change after message receipt. Overall, participants had approximately four belief changes (untransformed median value) during the postmessage phase. Responding to a mixed-valence message, participants had approximately six belief changes (untransformed median value) during this phase. These results suggested that the process of belief change is dynamic rather than static.

As predicted, an oscillatory pattern of belief change during the postmessage phase was found. Overall, about one in four belief changes during the postmessage phase was followed by a belief change in the opposite direction. In the mixed-valence condition, the proportion of direction-change movements was greater, about one in three. These results generally support the spatial-linkage model of cognitive forces (Kaplowitz et al., 1983). The proportion of changes in direction indicated that there were approximately three belief changes in one direction before the direction of belief change was reversed. In other words, the observed pattern was a combination of three unidirectional movements followed by a change in direction. The self-generated attitude change model (Tesser, 1978) suggests a unidirectional pattern of belief change during judgment, especially in response to univalent (Vallacher et al., 1994) or schema-consistent messages. The relatively low proportion of changes in direction in the univalent-message condition (about one in five) provides limited support for the self-generated attitude change model.

Cognitive activities after message receipt and before final judgment are little known but of great interest to persuasion theorists. The effect of message variables on belief change is most likely to be mediated by those cognitive activities (see the cognitive response model; Petty et al., 1981). The current study found an oscillatory pattern of belief change during the postmessage phase, which provides some clues about cognitive activities. The observed oscillatory pattern of belief change suggests that people have both positive and negative thoughts about an issue after message receipt not only for two-sided (mixed-valence) messages but also for one-sided (univalent) messages. Furthermore, we showed that these postmessage cognitive activities are predictable by at least one message characteristic, message valence.

This study also has practical implications. In a typical persuasion experiment, participants are asked to indicate their position about the target issue only once after being exposed to a message; in general, the participant's response is requested immediately after message receipt. However, we have shown that a belief continues to change after message receipt, achieving a new equilibrium value about one full minute later. Therefore, investigators need to give participants enough time to think about a message if what is presumed to be measured is the belief's new equilibrium value.

The cognitive response model and the number of belief changes during judgment

Two hypotheses regarding belief change during the postmessage phase (H5 and H6) were based on the cognitive response model (Petty et al., 1981). Message recipients were assumed to have had cognitive responses during the postmessage phase, and those cognitive responses resulted in belief change that were reflected in the belief trajectories. Responding to the positively univalent message, more positive belief changes were generated than negative belief changes. On the other hand, responding to the mixed-valence message, there was no significant difference between the number of positive and the negative belief changes (H5). Because a more difficult decision should generate more cognitive responses during the postmessage phase, there should be, and were, more belief changes in the belief trajectories based on the mixed-valence message than in the trajectories based on the univalent message (H6). The results provide support for the cognitive response model.

Limitations

Measurement of information weight

The present study applied information integration theory (Anderson, 1971) to predict belief change during message receipt. According to information integration theory, the weight and the value of pieces of information in the message are two key determinants factors of belief change. In the present study, the weights of the pieces of information were not measured. Even though the model with only values for the pieces of information in the message performed reasonably well, incorporating the weights of the pieces of information should make the model more effective.

Number of movements and possible sample bias

The observed trajectories were highly complex. To simplify belief trajectories, some key positions were extracted from thousands of belief positions. Local movements were used, which also provided information about positive and negative belief change. However, the local movement framework limited the analyses in two ways. First, some participants did not make many local movements. As a result, the number of time points examined was limited to six during message receipt and to three in the postmessage phase. Second, data from participants who made fewer local movements than the number that was used in the analyses had to be omitted. Even though those cases may be considered outliers, it seems fair to conclude that the findings of the present study may not apply to individuals who are rigid or who fail to change their views at least to some extent in response to the information in the message (see Hunter, Levine, & Sayers, 1976).

Difficulties of assessing reliability

Even though the results of hypothesis testing provided evidence of the construct validity of the computer mouse measurement, the degree of reliability of the measurement in terms of a number like Cronbach's alpha is not known. Test–retest reliability could be obtained by presenting a similar decision problem on two different occasions, although this method has its own difficulties: Any differences found may be due to occasion-specific factors rather than to instantaneous unreliability (see, e.g., Wheaton, Muthén, Alwin, & Summers, 1977). Nevertheless, methods to assess the reliability of the computer mouse technique need to be developed.

Assessing methods biases
To assess any bias that is generated by the computer mouse technique, the final belief position of individuals asked to indicate belief change during judgment using the computer mouse technique and of individuals not measured during judgment could be compared. This method would provide evidence of the generalizability of the belief-change measure (i.e., the extent to which the belief outcome is influenced by the artifacts of the laboratory and its procedures), but the internal validity of the current study would not be affected by this analysis. Nevertheless, information about such biases is valuable and should be obtained.

Conclusion

Cognitive activities during message processing are one of the most interesting problems in persuasion, but there is very little information about this process. In particular, effective measurement tools are needed to observe cognitive activities and message processing. In this study, differences in cognitive activities caused by univalent messages and mixed-valence messages and during the message-receipt phase and the postmessage phase were captured by belief trajectories. Cognitive activities as affected by other persuasion variables can also be revealed by this new measurement tool. As the Coleman (1968) epigraph suggests, the observation of beliefs and other persuasion variables over time allows for a significant account of the causal relationships between belief change and those persuasion variables; it is up to the investigator to use these observations effectively to create and test theory.

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Notes

1 This model is very simple in that it assumes that there is no systematic effect of self-generated cognitive responses on beliefs during message receipt. In other words, it is assumed that it is the external information (i.e., the information in the message) rather than internally generated information (i.e., cognitive responses) that determine the trajectory of belief change during the message-receipt phase. If cognitive responses simply reflect the information in the message and if participants are homogeneous with regard to their responses to this information, then the above assumption is quite reasonable. If the model based on this assumption does a poor job of fitting the data, then this assumption might reasonably be questioned, but that possibility is an empirical matter. For discussion of an opposing view, see Petty, Briñol, and Tormala (2002).

2 These induction check results are from McGreevy (1996, p. 157). Analyses of covariance were conducted for manipulation checks in which each manipulation check measure was predicted by two independent variables, message type and distraction, and one covariate, individual need for closure, $N = 102$. For individual need for closure, the Need for Closure Scale (Webster & Kruglanski, 1994) was used. For more information, see McGreevy (1996, p. 141).

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La dynamique cognitive des croyances : L’effet de l’information sur le traitement du message

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Résumé

Cette recherche a étudié la chronologie du changement de croyance face à des messages monovalents comparativement à des messages à valence mixte, à la fois au moment où le message était reçu et après réception, pendant qu’il était pris en considération. Les hypothèses à propos des schémas temporels de changement de croyance furent testées à partir des trajectoires de croyance de McGreevy (1996), *N* valide = 78, avec en moyenne un nombre de points de temps par personne de 5 267 (126,41 sec.) pour la phase de réception du message et de 2 467 (59,22 sec.) pour la phase post-message. Les résultats ont démontré qu’au moment de recevoir un message, les croyances changeaient selon la valeur et l’ordre de présentation de l’information dans le message. Un nombre plus élevé de changements positifs de croyances fut généré en réponse à un message monovalent positif qu’à un message à valence mixte. Durant la phase post-message, un schéma oscillatoire plus grand du changement de croyances fut observé pour un message à valence mixte que pour un message monovalent. Les implications théoriques et méthodologiques de ces résultats sont discutées.

Las Dinámicas Cognitivas de las Creencias: El Efecto de la Información sobre el Procesamiento de los Mensajes

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Resumen

Este estudio investiga el curso del cambio de creencias a través del tiempo de los mensajes de una valencia versus valencias mixtas, ambos mientras el mensaje está siendo recibido y después de su recepción mientras está siendo considerado. Las hipótesis acerca de las pautas temporales de cambio de creencia fueron puestas a prueba con las trayectorias de creencia de McGreevy (1996), válido $N = 78$, con un número de puntos de tiempo promedio por persona = 5,267 (126.41 s) para la fase de recibo del mensaje y 2,467 (59.22 s) para la fase después del mensaje. Los resultados demostraron que mientras se recibe un mensaje, las creencias cambiaron de acuerdo al valor y al orden de la presentación de la información en el mensaje. Un número mayor de cambio de creencias positivas fue generado en respuesta a un mensaje positivo univalente que a un mensaje de valencias mixta. En la fase después del mensaje una pauta mayor de oscilación de cambio de creencia fue hallada en los mensajes de valencias mixtas que en un mensaje univalente. Las implicaciones teóricas y metodológicas de estos hallazgos son discutidas.

信仰的认知永动性：信息对信息处理的影响

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本研究调查了单情感值**与多**情感值**信息所引起的**信仰变化的时间过程，包括信息被接受阶段以及接受以后被考虑的阶段的变化。我们用McGreevy （1996）的信仰轨线对信仰变化之瞬间模式加以检验：有效样本数为78；在信息被接受阶段，每人的平均时间点为 5,267 (126.41 s)，在信息接受之后的阶段，每人的平均时间点为2,467 (59.22 s)。 结果表明：接受信息的时候，信仰依信息表达的价值和次序而变化。信仰正变化更多地源自对单值信息而非多值信息的反应。在信息接受之后的阶段，信仰变化的模式更多地源自多值信息而非单值信息。我们讨论了这些发现的理论和方法上的涵义。

신뢰의 인지적 역동성: 메시지 과정화에서 정보효과에 관한 연구

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요약

본 연구는 단일 메시지 대 혼합된 메시지로부터 신뢰 변화의 과정에 대한 연구인바, 메시지들이 받아들여질때와 메시지 수신후 고려될때 모두에 관한 것이다. 신뢰변화의 임시적 형태에 관한 가정들은McGreevy (1996)의 신뢰 추적에 의해 시험되었는바, 샘플 사이즈는 모두 78이며 메시지 수신단계에서 일인당 평균시간 포인트는 5,267 (126.41s)이었다. 메시지 수신후 평균은 2,467 (59.22 s) 이었다. 연구 결과, 메시지를 수신하면서 신뢰들은 메시지에서의 정보 발표 순서와 가치에 따라 변화한다는 것을 보여주고 있다. 상당한 정도의 긍적적인 신뢰의 변화는 혼합된 메시지보다 긍정적인 단일메시지에 대한 반응에 의해 산출되었다. 메시지 수신후 상태의 경우 신뢰변화의 커다란 동요형태가 단일 메시지보다는 혼합된 메시지에서 발견되었다. 이러한 발견들의 이론적 그리고 방법론적 함의들이 논의되었다.