A Connectionist Model of Attitude Strength and Change

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Abstract

A localist constraint satisfaction neural network model is presented to account for a broad collection of attitude and attitude change phenomena. Activations and weights among units in the recurrent network are used to vary the structure and properties of the attitude and a persuasive message. The model uses Hebbian learning to update weights, allowing it to represent long term changes in attitude as well as temporary construction of attitudes. Phenomena modeled include attitude strength, motivated reasoning, and heuristic vs. systematic persuasion. The same set of simple mechanisms is used to model all the phenomena, which allows the model to offer a parsimonious theoretical account of much of the literature on attitude change. The model also provides a specified structural description of attitudes that could lead to new predictions and a more complete understanding of the construct and its effects.

Keywords: social cognition; attitudes; computer simulation; neural networks.

Introduction

Attitudes are not just important to social psychology researchers, but have very immediate and practical implications for everyday life: from stereotypes and prejudice to even larger scale human relations, such as politics, international conflicts, and acts of terrorism. Currently in social psychology there is no general theory of attitudes.

Existing theoretical models of attitude change, such as the Elaboration Likelihood Model (ELM; Petty & Cacioppo, 1986) and Heuristic-Systematic Model (HSM; Chaiken, 1980; Chen & Chaiken, 1999) specify many postulates that address under which conditions attitudes might be more likely to change. Factors that influence the degree of attitude change include characteristics of the persuasive message, characteristics of the source of that message (such as credibility), and characteristics of the message receiver. Multiple pathways to persuasion have been identified and integrated into these models; some involve a minimal amount of thought and others involve quite elaborate, deliberate thought (Chaiken, 1980; Fazio, 1990; Petty & Cacioppo, 1986). The causes and effects of attitude change are not simply predicted though, and most often rest on contingent relationships between factors. These are not models that offer an explanation of the actual process involved. The antecedents of attitude strength are complex as well, the basis of which has proved to be far richer than the sheer amount of knowledge or related experience (Krosnick et al. 1993; Krosnick & Petty, 1995).

The current state of attitude research, while sophisticated with respect to the concepts it invokes, ultimately rests not on a unified framework of precise mechanisms, but instead on a set of moderating variables and messy interactions that does not allow more precise prediction. Here I use a connectionist model to account for many of the phenomena with one framework.

There are many reasons to think of attitudes as associative networks. I believe the existing research and evidence clearly suggests this kind of formulation. For example, elaboration has been found to be extremely important in predicting many attitude measures (Petty, Haugtvedt, & Smith, 1995), and specifically imparts more substantial and complex internal structure to attitudes (Wegener, Petty, Smoak, & Fabrigar, 2004). Processing of attitude information often proceeds in parallel (Holyoak & Simon, 1999), just as would be expected from a network. Attitudes appear to exhibit constraint satisfaction behavior (Kunda & Thagard, 1996; Simon, Snow, & Read, 2004) and nonlinear effects (Vallacher, Nowak, & Kaufman, 1994).

Constraint satisfaction models have been used previously to model limited and specific phenomena related to attitudes. These include cognitive dissonance (Shultz & Lepper, 1996), stereotype acquisition (Queller & Smith, 2002), and hypothesis evaluation (Thagard, 1989). The current model uses a general architecture in a more comprehensive attempt to account for a wider range of attitude phenomena, and in the process offer a parsimonious theoretical unification that is currently lacking, rather than a painstaking reproduction of laboratory results.

The Model

Architecture

The model (Figure 1) uses a recurrent localist connectionist architecture and consists of 102 interconnected units. They are organized into 4 layers for clarity of process and procedural considerations. One unit represents the attitude object. Another unit represents an evaluation dimension. This is consistent with virtually all current attitude theorizing, which says an attitude, minimally, is composed of a target entity or issue, and a connected evaluative component (e.g. Fazio, 1990).

The evaluation unit represents not a general good-bad continuum, but the specific dimension of evaluation. Several dimensions could potentially be evaluated at the same time, although this is not explored here. The remaining 100 units are divided up into two parcels: an 80-unit cognitorium (the entire network of cognitions relevant to an attitude) and a 20-unit parcel representing persuasive communications. Both the cognitorium and the persuasive communication have equal stature in the model in terms of their connectivity to the attitude object and the evaluation dimension. All units in both layers are intended to be the same kind of thoughts. The distinction is made for conceptual clarity and operational convenience. Units in the model represent abstract features or objects.

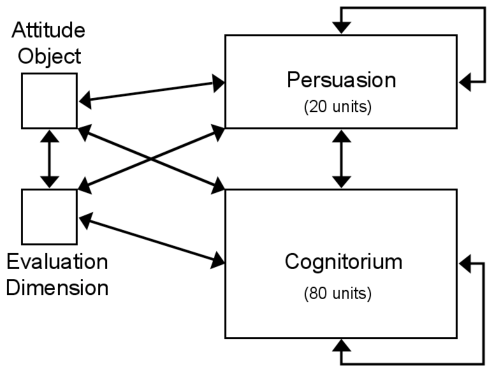

Figure 1: The attitude model.

Dynamics and Learning

Activations vary between -1 and +1. Weights vary between -1 and +1. Activation is governed by a sigmoidal activation function and updates over a series of cycles until activation settles. After settling, weights update using an unsupervised Hebbian learning rule.

Assessment

Assessment of the model is carried out primarily by measuring the activation on the evaluation unit at the end of the settling process. This represents a typical (explicit) attitude measure. So if the attitude object is the President of the United States, and the evaluation dimension is his worth as a human being, a positive activation of the evaluation unit corresponds to endorsing the attitude that the President is a fine human being, and a negative activation on that unit corresponds to the agent feeling that the President is a horrible person. Activations of the other units are examined to understand the processes occurring in the model. Each activation of an individual unit in the cognitorium represents the activation of a cognition.

Additional Properties

The attitude object is given special status in the model, and mainly functions as an organized way to inject activation into the rest of the network. Its fixed activation represents the idea that it is constantly in awareness as processing occurs. The attitude object is also connected to the objects in the cognitorium and persuasion communication with exclusively positive weights, for a practical reason. This was done so the activation can be injected into the network in a way that ensures these activations are positive, so the relationship between the attitude and the other cognitions can be controlled more precisely and the constraints applied by the weights below work in a conceptually clear way (for example, since the weights come from a distribution (Table 1) and are not individually controlled, if some of the weights between the attitude object and the cognitorium were negative, and the weights from some of those cognitorium units to the evaluation were also negative, it would indirectly be giving the evaluation unintended positive activation).

Table 1: Initialized Weights

Layers	Initialized Values	Distribution Function	Learning Rate
AO-Cogn	.02 ± .1*	Uniform	0.1
AO-Pers	.05 ± .05	Uniform	0.1
Cogn-Pers	0 ± .1	Uniform	0.1
Cogn lateral	0 ± .1	Uniform	0.1
Pers lateral	0 ± .1	Uniform	0.1
Eval-Cogn	Vary	Gaussian	0
Eval-Pers	Vary	Gaussian	0
AO-Eval	0	--	0.2

The weights have been initialized in the following way to facilitate the specific tasks the model is designed to explore: The weight distribution between the attitude object and the units in the cognitorium and the units in the persuasion layers is truncated to the range 0 to 1. The weights between the attitude object and the cognitorium ensure the association between the attitude and the objects in the cognitorium is positive as mentioned previously, but also that there is a wide variation in weights and that many of the cognitorium units initially have no association with the attitude object. The weights between the attitude object and the persuasive communication ensure that all cognitions in the persuasion layer have positive weights to the attitude object; this in turn ensures they are relevant to the attitude in a consistent way. The weight between the attitude object and the evaluation starts at zero, which ensures that evaluation of the attitude object is a result of the cognitions in the cognitorium and the learning process. The weights between the cognitorium and the evaluation vary from simulation to simulation but generally have a positive mean value, and do not learn. This ensures that the attitude (which is based on the cognitorium) will be predisposed in the positive direction, in the absence of any persuasion. The weights between the persuasion layer and the evaluation node are initialized from a Gaussian distribution, and depend on the particular simulation. This special treatment has to do with the different proposed types of persuasion. They do not learn, and will be described as appropriate. Finally, the lateral weights among the cognitorium units, the lateral weights among the units in the persuasion layer, and the weights between the cognitorium and the persuasion layer are all treated the same; they represent a variety of possible relations, both positive and negative. This emphasizes that the cognitorium units are not different from the persuasion units, other than their initial evaluative bias (because the essence of a persuasion is that its evaluation varies from the existing beliefs) and slight differences in the associative distribution with the attitude object (which again will be discussed for each appropriate simulation).

Simulations

A set of simulations was chosen to represent a broad range of attitude phenomena. The goal of these simulations is to successfully show that constraint satisfaction processes and other emergent properties of connectionist networks can account for the covered attitude phenomena. The simulations are 1) attitude structure and strength, 2) motivated reasoning, and 3) heuristic vs. systematic persuasion. This suite of simulations was chosen because it demonstrates some of the most basic properties of attitudes and could be used as a jumping-off point for any number of other more advanced simulations.

Simulation 1: Attitude Strength

One of the defining attributes of attitude strength is that stronger attitudes tend to resist persuasive attempts. In this simulation, I wanted to show that while keeping the persuasive attempt the same across conditions, the degree of interconnectedness between cognitions in the cognitorium and the accompanying strength of the attitude would moderate the amount of attitude change.

In this simulation, there were four conditions. One corresponded to no existing attitude, and the other three corresponded to existing attitudes of various strengths: low, medium, and high. For this simulation, a preliminary phase had to be run for the purpose of inducing (or learning) the initial attitude. This was done by repeatedly activating the attitude object and letting activation spread throughout the network until it settled. Weights would update for as many trials as needed. Through this process, the evaluation would polarize on its own. This result is extremely similar to the behavior examined in the context of self-generated attitude polarization (Tesser, 1978). For the low strength condition, the network was initialized and the attitude unit was activated repeatedly until the evaluation unit polarized to an activation of .104. For the medium and high strength conditions, the same weight initialization was used; the attitude was allowed to polarize until activation reached .18 and .28, respectively. The weights between the persuasion and the evaluation were initialized from a Gaussian distribution with a mean of –0.1 and a variance of 0.02. This ensured that the evaluative implication of the persuasion was negative, regardless of the randomization. Twenty different runs were performed in each condition, each with a different initialization of these weights. To represent the actual persuasion attempt, three units out of 20 in the persuasion layer were externally fully activated, as well as the attitude object.

Attitudes were assessed two different ways. In the first, activation of the evaluation unit was taken when the network settled after activating the persuasion, as above. This corresponds to someone being asked their opinion immediately upon receipt of the persuasive message. In the second method, after this settling, weights were allowed to update, activation was reset at 0, and then only the attitude object was given external activation. The network was allowed to settle at which point activation of the evaluation unit was measured. This second method represents a delayed assessment, as if someone were asked about their attitude long after the persuasion episode occurred.

Table 2: Simulation 1 Results

	Condition			
Measure	No Train	Low Train	Mid Train	High Train
AC Method 1	.202[a]	.179[a]	.143[b]	.076[c]
AC Method 2	.055[a]	.033[a]	-.032[b]	-.127[c]
CUA Method 1	.90[d]	8.15[c]	23.25[b]	41.40[a]
CUA Method 2	0[d]	8.75[c]	33.50[b]	52.55[a]

Notes. AC=Attitude Change. CUA=Cognitorium Units Active. Values that do not share superscripts within each row differ at p <.01. Values that do share superscripts are not significantly different. Positive values of attitude change should be interpreted as greater persuasion.

As shown in Table 2, attitude change using the first method was greatest in the condition where the attitude was initially non-existent. Change in the low strength condition was not significantly different from the no train condition. The attitude changed significantly less in the medium strength condition, and least of all in the high strength condition. When attitudes were measured using the second method, one sees that change in the direction of the persuasion does take place in the zero and low-strength conditions, the moderate strength condition shows slight polarization in the direction of the initial attitude, and the high strength condition polarizes in this direction even more. The number of units in the cognitorium which become active also consistently increases as strength increases. The number of cycles the network took to settle also generally increased as attitude strength increased, corresponding to the amount of time the course of thought took—the better-developed the attitude was, the more processing was required to sort out the communication.

Discussion. This simulation showed that persuasion attempts do not affect all networks equally. The networks that had more opportunity to self-organize (and thus had stronger attitudes) resisted the change in the direction of the persuasion. During the training of the networks, an increased number of thinking events led to more activation flowing through the network, and due to the weight update rule, the overall weights in the model increased. These self-organized and stable patterns of weights prevented the welldeveloped attitudes from changing as much as the minimally-developed attitudes. This is the essence of the constraint satisfaction process as it relates to attitudes. This mechanism is likely responsible for many effects where elaborated attitudes are harder to change.

Simulation 2: Motivated Reasoning

In the first simulation, the effects depended on a general constraint satisfaction mechanism. Greater connectivity imparts greater constraint, and thus greater stability. In certain cases, more specific constraints are important, for example the constraint supplied by having a particular belief. A clear example of this is the domain of motivated reasoning. Generally, motivated reasoning can be thought of as an individual coming to a conclusion that is desired or congenial with existing beliefs. An example of this would be the propensity of two groups of fans watching their favorite sports teams play each other coming to different conclusions (that help their favored team) on rule infractions or other judgment calls, after watching the same exact play; this kind of bias is undoubtedly driven by the differing goals that the observers have. This has been identified as a candidate for constraint satisfaction processes (Kunda & Thagard, 1996) and phenomena such as impression formation biased by stereotypes have already been modeled by other networks. Kunda and Thagard (1996) have suggested that this biased processing is handled automatically as a result of the natural interaction of all relevant cognitions. This reasoning is extended to the present simulations. It is proposed that existing beliefs and/or goals naturally constrain or bias processing in such a way that the individual reaches the conclusion which is congenial with these beliefs; in other words, people will come to the conclusion that they desire.

To show that goals and strongly held beliefs would affect the processing related to a persuasive attempt, the standard persuasion process was implemented, and then modified in the following way. One unit in the cognitorium was designated as a "biased" unit. This can be thought of as a goal, or some other belief or thought that is highly related to a particular evaluation. The weight from this unit to the evaluation unit was fixed at 0.5, which is much stronger than any of the other weights; this represented the strong relation between the two; all other weights to this unit were determined normally from the initializing distributions. During the persuasion attempt, this special unit had its activation manipulated externally (as with the attitude object) to control whether the network was "using" this particular thought. In the control condition, the persuasion was run without this unit activated. In a second condition (cognitorium-biased), the biased unit was given positive activation, and in a third condition (persuasion-biased), the unit was given negative activation. This negative activation can be thought of as activating the cognition opposite to that same unit when there is positive activation. Thus there were three conditions: one where the biased unit was positively related to the existing attitude, thus presumably biasing the network to keep its existing position, one where the biased unit was negatively related to the existing attitude and biased in the direction of the persuasion attempt, and a third where no special activation was given to the biased unit.

Table 3: Simulation 2 Results.

	Condition		
Measure	Cognitorium Bias	No Bias	Persuasion Bias
AC Method 1	-.003[c]	.170[b]	.343[a]
AC Method 2	-.021[c]	.014[b]	.036[a]
CUA Method 1	14.30[a]	9.45[b#]	6.85[b#]
CUA Method 2	12.70[b]	14.90[ab]	15.95[a]

Notes. AC=Attitude Change. CUA=Cognitorium Units Active. Values that do not share superscripts within each row differ at $p < .01$. Values that do share superscripts are not significantly different. Positive values of attitude change should be interpreted as greater persuasion.
values in these conditions differ at $p < .05$.

The results from simulation 2 are presented in Table 3. Using the first attitude assessment method, the cognitorium-biased processing resulted in less attitude change than the no bias condition, which in turn resulted in less attitude change than the persuasion-biased condition. More cognitorium units exceeded threshold in the cognitorium-biased condition than the two other conditions. Using the second (delayed) attitude assessment method, persuasion was least effective in the cognitorium-biased condition, followed by the no bias condition, and most effective in the persuasion-biased condition. Not surprisingly, in the cognitorium-biased condition more cognitorium units were active, and in the persuasion-biased condition more persuasion units were active. This is in line with the notion that an individual will arrive at a conclusion consistent with the evaluation that is necessitated by their beliefs.

Discussion. The motivated reasoning simulation showed how strongly held beliefs and goals can influence the state of the overall network. The combination of a strong weight and sufficient activation drove the state of the network to be consistent with a single node. The evaluation of an entire attitude was influenced by a single cognition, measured using both attitude assessment methods; the second method showed influence due to weigh change even after the cognition was no longer active. Thus the temporary activation of a cognition more permanently influenced an evaluation. This simulation suggests that biased judgment effects do not need a special form of processing. Biased judgments are guided by the activations and weights that happen to strongly favor one conclusion over the other.

Simulation 3: Heuristic vs. Systematic Processing

Both the Elaboration Likelihood Model (Petty & Cacioppo, 1986) and the Heuristic-Systematic Model (Chaiken, 1980, Chen & Chaiken, 1999) argue that there are two important routes toward attitude change. The first route requires concentrated cognitive effort and attention and comprehension of the central message. The second route is much less effortful, only using learned cognitive shortcuts (heuristics) or other processing mechanisms that require minimal effort. Both models suggest that the type of change these routes to persuasion induce are not the same, for example stating that the more cognitive effort that is involved in processing the message, the more stable the resulting attitude will be. However, a competing theory, dubbed the Unimodel of persuasion (Kruglanski & Thompson, 1999) claims that there is only one processing mechanism, and the two types of persuasion suggested by the above models are the same but only vary in complexity. A network model like the present one might help clarify this debate if it is able to handle the two "different" types of persuasion in the same framework, and explain how and why the processes differ.

I attempted to implement the two different forms of persuasion: systematic/effortful and heuristic/low effort. The implementation of the persuasive messages is different, but I was careful to set up the two persuasion attempts so that they would have equivalent impacts on the activation of the evaluation node. We did this so that we could test the possibility that even when the two forms of persuasion had an equivalent impact on an evaluation, they might have different impacts on the persistence or stability of attitude change. Since both dual process models under consideration argue that the more effortful persuasion should produce a more persistent attitude, a second persuasion attempt was implemented to try to move the evaluation back in the direction of the initial attitude and confirm these predictions.

To capture these differences in forms of persuasion, in the heuristic persuasion condition the weights between the evaluation unit and the persuasion layer came from a distribution with a mean of -0.25 and a variance of 0.02. Weights within the persuasion layer had a mean of 0 and a variance of 0.1. The high weights (-0.25) help represent the strong associations mentioned above, while the low weights within the persuasion layer represent the simple, unconnected nature of these associations. In the systematic condition, evaluation-persuasion weights had a mean of –0.05 and a variance of 0.02 showing that the persuasion units were not as directly related to the evaluation, and weights among the persuasion units had a mean of 0.1 and a variance of 0.1 showing the persuasion units were more related to each other as in an integrated argument. The network was initialized so that the pre-persuasion attitude was identical across conditions. The persuasive message was implemented with the same activation patterns as in the previous simulations, with three active units in the persuasion layer. In the systematic condition, this would result in more units not in the original message being recruited, because of the strong weights between the units in the persuasion layer.

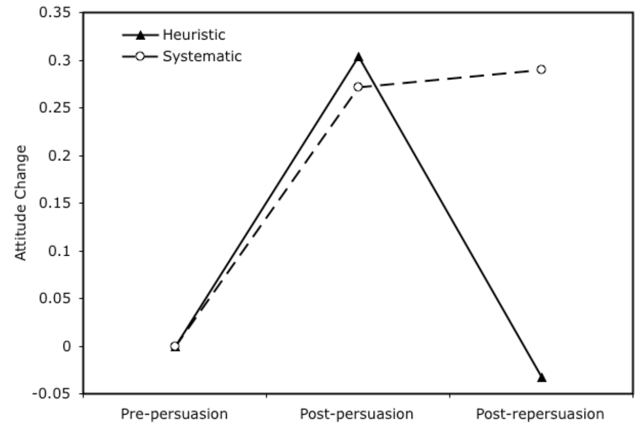

Figure 2: Simulation 3 Results.

In both the heuristic and systematic conditions, the attitude changed by approximately the same amount (see Figure 2). This shows that attitude change can be accomplished using two different types of persuasive messages: One which is mainly associative and simple, and the other where the evaluative implication is not as direct, but is achieved through the increased amount of processing recruiting more units. To investigate the temporal stability of the attitudes, the second persuasion attempt was implemented after the attitude changed due to the initial persuasion. This re-persuasion was the same across the two conditions. The results of the re-persuasion attempt (also see Figure 2) show much more stability in the systematic condition than in the heuristic condition.

Discussion. This simulation suggests that the different routes to persuasion can be accomplished merely by changing some parameters within the same framework, and using the same mechanism. While implementation of both types of persuasion led to attitude change, the differences were the interesting aspect of the simulation. In the systematic persuasion, the weights among the persuasion units were higher than they were in the heuristic persuasion. This pattern of weights recruited more units from the persuasion layer and from the cognitorium, and resulted in deeper processing. While the activation on the evaluation unit changed comparably across conditions, in the effortful condition the weights throughout a larger segment of the network changed more as a result of this increased processing. Because of this, the attitude resulting from the systematic persuasion was not as susceptible to re-persuasion. Weights controlling the stability of the attitude system is consistent with the results from simulation 1.

Discussion and Conclusion

The model starts from the premise that all relevant cognitions are organized in a recurrent network. This allows activation to spread through the connections and change the activation of the attitude as well as of any other unit in the network. The impact of this spreading is most notable in the process of attitude inducement (sim 1) where it is what allows the network to self-organize, and in the complex persuasive message of the systematic persuasion simulation where the weights allow the message to recruit other cognitions in the persuasion and cognitorium layers. Constraint satisfaction follows from this spreading activation, and can be due either to the weights throughout the cognitorium as in the attitude strength simulations where they provide stable structures that resist persuasion, or to a single unit as in the motivated reasoning simulation.

The simulations point to the fact that both the activations and the weights are each critical to understanding the behavior of the network and the corresponding attitude. The momentary activation of the network is due to more than just the pattern of weights because of the constraint processes acting to organize them, and the weight change is equally important in understanding the temporal stability of attitude change, most notably demonstrated in the different persuasion units in simulation 3, where increased weight change due to the systematic processing led to a more stable long-term attitude.

Creating models to account for the general mechanisms by which attitudes gain their strength and also change has not been a focus of attitude research in social psychology. It is believed that this model makes a significant theoretical contribution. The simulations represent attitudes in a more specified way, and the method allows us to isolate and identify structural features and how they evolve during persuasion, giving us a better picture of the components responsible for strength and change. It is believed this model highlights the ability for models using simple mechanisms to be built up to account for what are traditionally seen as complex phenomena not amenable to concise explanations. According to this model, attitudes at a fundamental level may be much simpler to explain than previously thought.

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