A Network Perspective on Political Attitudes: Testing the Connectivity Hypothesis

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One of the key concepts in the research on political attitudes is attitude strength. Strong attitudes are durable and impactful, while weak attitudes are fluctuating and inconsequential. Recently, the Causal Attitude Network (CAN) model was proposed as a comprehensive measurement model of attitudes. In this model, attitudes are conceptualized as networks of causally connected evaluative reactions (i.e., beliefs, feelings, and behavior toward an attitude object). Here, we test the central postulate of the CAN model that strong attitudes correspond to highly connected attitude networks. We use data from the American National Election Studies 1980-2012 on attitudes toward presidential candidates (total \( n = 18,795 \)). The results show that attitude strength and connectivity of attitude networks are strongly related. Additional analyses show that connections between non-behavioral evaluative reactions (i.e., beliefs and feelings toward presidential candidates) are highly predictive of the connections between behavior (i.e., voting decisions) and non-behavioral evaluative reactions. This result indicates that connectivity of political attitude networks accounts for differences between strong and weak attitudes in attitude-behavior consistency with respect to voting decisions. We conclude that network theory provides a promising framework to advance the understanding of attitude strength.

While some political attitudes are durable and have impact on (voting) behavior, other political attitudes are largely inconsequential and fluctuating—in short, political attitudes (like other attitudes) differ in their strength. These fundamental differences between strong and weak attitudes have spurred decennia of research in Political and Social Psychology and many different attributes have been identified that are related to attitude strength (e.g., importance, certainty, accessibility; for overviews see Cunningham & Luttrell, 2015; Krosnick & Petty, 1995; Visser, Bizer, & Krosnick, 2006). Recently, the Causal Attitude Network (CAN) model, in which attitudes are conceptualized as networks of causally related evaluative reactions (i.e., beliefs, feelings, behaviors toward an attitude object; Dalege et al., 2016), has been proposed as a comprehensive measurement model of attitude. The CAN model holds that connectivity of attitude networks represents a formalized conceptualization of attitude strength. Here, we take the CAN model to the stage of political attitudes and provide a first test whether strong (political) attitudes indeed correspond to highly connected attitude networks. Additionally, we test whether the connectivity conceptualization accounts for the difference in attitude-behavior consistency of strong and weak political attitudes.

The Causal Attitude Network (CAN) Model

The basic premise of the CAN model is that an attitude is a system of evaluative reactions that influence each other (Dalege et al., 2016). Network modeling offers a natural representation of this hypothesis, because in network models, complex systems are modeled as a set of autonomous entities (i.e., nodes) and connections between these nodes (i.e., edges). The network structure is based on the set of nodes and edges (Newman, 2010) and modeling psychological phenomena with networks has proven to be successful in different subfields of psychology (e.g., Cramer et al., 2012; Cramer, Waldorp, van der Maas, & Borsboom, 2010; van der Maas et al., 2006).

In attitude networks, nodes refer to evaluative reactions such as judging a presidential candidate as competent, charismatic and honest; feeling hope and pride about a presidential candidate; and showing support and voting for a presidential candidate. The CAN model holds that the Ising-model (Ising, 1925) provides a framework for modeling the dynamics of attitudes (Dalege et al., 2016). Originating from statistical physics, the Ising-model constitutes the Markov Random Field network model for binary data (Kindermann & Snell, 1980). In the original formulation of the Ising-model for binary variables, nodes can be in one of two states (+1, -1) – in the case of attitudes, evaluative reactions as described in test items can be either endorsed or not endorsed. Edges in attitude networks represent bidirectional pairwise interactions between evaluative reactions (e.g., feeling hope about a presidential candidate may result from one’s judgment of the president as being honest and vice versa).

In the Ising-model, edges can be either positive (representing excitatory influence between evaluative reactions) or negative (representing inhibitory influence between evaluative reactions) and can have varying weights representing the strength of the influence. High weights between two given evaluative reactions make it likely that, over time, the nodes will assume a stable configuration in which they assume the same (different) state when the edge is positive (negative). Attitude networks, as formulated in the Ising-model, thus strive for a consistent attitudinal representation when nodes of the same valence (e.g., judging a presidential candidate as honest and feeling hopeful toward her) are positively connected and nodes of different valence (e.g., judging a presidential candidate as honest and feeling angry toward her) are negatively connected.

In the CAN model, the average level of the weights depends on how often an individual interacts with the attitude object in one way or another (e.g., thinking about or perceiving the attitude object). Based on the mechanism...
of constraint satisfaction that was implemented in a recent connectionist model of attitudes (Monroe & Read, 2008; see also Cunningham & Zelazo, 2007 for a related neuroanatomical model), the CAN model proposes that connections between evaluative reactions self-organize when the individual interacts with the attitude object. Attributes related to attitude strength, such as importance (Boninger, Krosnick, Berent, & Fabrigar, 1995) and elaboration (Petty, Haugtvedt, & Smith, 1995), make it likely that an individual interacts with the attitude object and that the global connectivity of his or her attitude network increases as a result of this. Politically interested individuals are thus expected to have highly connected political attitudes.

**Global Connectivity of Attitude Networks**

The level of global connectivity is a primary aspect of networks. Global connectivity in networks depends both on the number of connections between nodes and on the magnitude of the connection weights. In highly connected networks, changes in one node have stronger effects on other nodes. Thus, in highly connected attitude networks, evaluative reactions have more causal impact on each other than in weakly connected attitude networks. As a result, nodes in highly connected networks typically align their states, while nodes in weakly connected networks can vary relatively independently and show more random patterns (e.g., Kindermann & Snell, 1980; Scheffer et al., 2012). Next we will illustrate what this means in the context of attitudes toward politicians, after which we will discuss why connectivity can be regarded as a formalized conceptualization of attitude strength.

Consider Alice and Bob, who both have a positive attitude toward Barack Obama. Suppose that both Alice’s and Bob’s evaluative reactions include judging Barack Obama as charismatic, honest and competent. Alice’s and Bob’s attitudes, however, differ in their connectivity – Alice’s network is highly connected while Bob’s network is weakly connected (see Figure 1 for a graphic representation). As a result, if Alice were to receive information that is incongruent with the current state of a given evaluative reaction – say, she learns of a mistake Barack Obama made, implying that Barack Obama might not be as competent as Alice initially thought – strong causal connections between the judgments would create an unstable state of the network (van Borkulo et al., 2014). To regain stability, Alice should either discard the information as unreliable or her other judgments should change, too – the former course of action, however, becomes more likely with increasing connectivity between the judgments up to the point where it becomes extremely difficult to change one of the evaluative reactions in isolation. If Bob, on the other hand, were to change his judgment that Barack Obama is competent, this change would not have much impact on his other judgments, because his network is weakly connected. Thus, conflicting evaluative reactions would disturb his attitude network to a much lesser extent, making it easier to change individual evaluative reactions. Highly connected attitudes thus result in consistent attitudes – an attribute that is related to attitude strength (Chaiken, Pomerantz, & Giner-Sorolla, 1995; Eagly & Chaiken, 1995; Judd & Krosnick, 1989; Judd, Krosnick, & Milburn, 1981). Network connectivity therefore provides a mechanistic explanation of why attitudes differ in their consistency (Dalege et al., 2016). In the discussion, we further elaborate on the different dynamics of highly and weakly connected attitude networks in response to persuasion attempts.

**Network Connectivity and Attitude Strength**

Dynamical properties of networks, such as their evolution in time and resistance to change, are intimately intertwined with network structure (e.g., Cramer et al., 2016; Kolaczyk, 2009; Manrubia & Mikhailov, 1999; Scheffer et al., 2012; Watts, 2002). It turns out that the dynamics of highly and weakly connected networks bear a striking resemblance to the defining features of strong and weak attitudes (Dalege et al., 2016).

First of all, strong attitudes are resistant to change (e.g., Bassili, 1996; Bizer & Petty, 2005; Visser & Krosnick, 1998). In networks, it is known that while weakly connected networks change roughly proportional to the external force put on the network’s nodes (e.g., a persuasive message regarding Obama’s incompetence), a disproportionate amount of force is needed to instigate change in highly connected networks (Cramer et al., 2016). Thus, revisiting the case of Alice and Bob, stronger persuasion would be needed to change any of Alice’s judgments, because the causal influence of the other judgments would be likely to have the nodes keep each other in check and render the persuasion attempt less successful. In contrast, Bob’s attitude could be easily and gradually changed (e.g., by directing persuasion attempts at each of the network nodes in turn).

Second, strong attitudes are highly stable – they persist over time (e.g., Bassili, 1996; Prislin, 1996). There are two reasons to expect that the same holds for highly connected attitude networks. First, resistance to change, as discussed above, will lead to higher stability over time in the overall state of the network. Second, individual nodes in weakly connected networks will intrinsically show more random variation than nodes in highly connected networks because their behavior is to a larger extent controlled by random perturbations from outside the network (Kindermann & Snell, 1980; van Borkulo et al., 2014).

Third, strong attitudes are better predictors of behavior than weak attitudes (e.g., Bizer, Larsen, & Petty, 2011; Fazio & Williams, 1986; Holland, Verplanken, & van Knippenberg, 2002). The reasons that highly connected attitude networks are more likely to guide behavior are three-fold. First, because in highly connected attitude networks all evaluative reactions need to align to the same evaluation, a highly connected attitude network tends to have a univalent overall evaluation. This makes it more likely that the attitude guides behavior. For example, if someone needs to decide for which presidential candidate she will vote, an attitude network consisting of aligned evaluative reactions will be more informative than an ambivalent atti-
Figure 1: Representation of evaluative reactions that are part of a highly connected (Alice) or weakly connected (Bob) attitude network. Thickness of edges represents strength of (reciprocal) causal connections between the evaluative reactions.

tude network consisting of conflicting evaluative reactions. Second, because weakly connected networks fluctuate over time, the attitude state measured at a given point in time may already have changed by the time the predicted behavior is executed, leading to a discrepancy between attitude and behavior. Third, because the CAN model treats behavior as part of the attitude network, factors that increase connectivity between non-behavioral evaluative reactions (i.e., beliefs and feelings) are expected to also influence the connectivity between non-behavioral evaluative reactions and behavioral evaluative reactions (e.g., behavioral decisions; Dalege, Borsboom, van Harreveld, Waldorp, & van der Maas, 2017).

The fourth similarity between the connection of networks on the one hand and attitude strength on the other lies in the fact that strong attitudes exert more influence on information processing – they direct attention and influence the way in which incoming information is integrated (Fazio & Williams, 1986; Houston & Fazio, 1989; Roskos-Ewoldsen & Fazio, 1992). While connectivity of attitude networks directly causes the former three features of attitude strength, the influence on information processing in our framework is probably indirect. As discussed above, successful persuasion is more likely to instigate conflict in highly connected networks. It is likely that individuals are motivated to avoid such conflict and are therefore motivated to integrate information in a way that does not disrupt the equilibrium of their attitude network. This motivation also might lead to heightened attention to attitude objects (e.g. candidates) to early detect “attacks” on the attitude network (e.g., campaigns).

Overview of the Present Research
In order to test the connectivity hypothesis, we applied network analysis to the open-access data of the American National Election Studies (ANES) between 1980–2012. These data sets involve large and representative sample sizes and focused on both theoretically and practically highly relevant attitudes – attitudes toward presidential candidates. Furthermore, the ANES were used in several earlier lines of research into attitude strength and related issues (e.g., Alwin & Krosnick, 1991; Bizer et al., 2004; Crano, 1997; Eaton, Visser, Krosnick, & Anand, 2009; Judd et al., 1981; Krosnick, 1988; Krosnick & Alwin, 1989; Lusk & Judd, 1988; Visser, Krosnick, & Simmons, 2003).

In Analysis 1, we tested the connectivity hypothesis, which holds that strong attitudes correspond to highly connected attitude networks. To create groups that could function as a proxy of attitude strength, we assigned participants to three attitude strength groups based on interest in political campaigns during the election year. Interest in political campaigns was shown to be a highly reliable indicator of general political interest (Judd et al., 1981), which in turn is positively related to attitude strength regarding attitudes toward presidential candidates (Lusk & Judd, 1988). We chose political interest because within the ANES it was the measure that was most closely related to attitude strength. Earlier findings have indicated that interest in an attitude object is a reliable indicator of attitude strength (Krosnick, Boninger, Chuang, Berent, & Carnot, 1993) and attitude importance has also been defined “as a person’s interest in or concern about an attitude” (Krosnick, 1988, p. 197). To assess whether the three groups (low, intermediate, and high in attitude strength) indeed differed in attitude strength, we compared the groups on three characteristics of attitude strength: We tested whether attitude stability differed between the groups, whether groups differed in their attitudes’ impact on (voting) behavior, and whether groups differed in terms of their attitudes’ extremity, as extremity is also regarded as a central property of attitude strength (e.g., Abelson, 1995; Bassili & Krosnick, 2000). We then estimated networks for each attitude strength group
at each election for each candidate, and compared the connectivity of these networks. The connectivity hypothesis predicts that attitude strength and connectivity are positively related.

In Analysis 2, we investigated whether the connectivity hypothesis can account for the probably most consequential difference between strong and weak attitudes – that strong attitudes are more predictive of behavior than weak attitudes. A recent study has shown that the impact of attitudes on behavior can be almost completely explained by differences in connectivity of the attitude networks (Dalege et al., 2017). Using a simulation study, it was shown that such a result could be expected when behavior represents a node in the attitude network. The reason that strong and weak attitudes differ in their impact on behavior might thus be that connections between behavior and other evaluative reactions are similar to connections between non-behavioral evaluative reactions, providing a parsimonious explanation for the differences in attitude-behavior consistency between strong and weak attitudes. To test this possibility, we estimated attitude networks, in which the voting decision of the participants was included as a node. We then tested whether the connection between the voting decision and other evaluative reactions is similar to connections in the attitude network excluding the voting decision.

Data and Variables

Participants

The ANES samples are large samples that are representative of the US American adult population. Questionnaires were administered in two surveys before and after each American presidential election from 1980 to 2012 by the Center for Political Studies of the University of Michigan. The samples to which all relevant items were administered in the pre-election survey consisted of 18,795 adult participants in total (see Table A1 in Appendix A for number of participants per election).

Measures

Relevant measures included non-behavioral evaluative reactions toward presidential candidates, a measurement of the interest participants had in the campaign, a global measure of the attitude toward presidential candidates, and a question that assessed whom the participants voted for.

Non-Behavioral Evaluative Reactions

Between six and 16 items tapping beliefs regarding the presidential candidates and between four and eight items tapping feelings toward the presidential candidates were assessed in the pre-election surveys of the different studies. Note that some items were administered in every ANES or in most ANES, while other items were only administered infrequently. A full list of the evaluative reactions can be found in Table A2 in Appendix A. Table A3 in Appendix A shows which evaluative reactions were assessed in which ANES.

For items tapping beliefs, participants were asked: “In your opinion, does the phrase ‘he/...’ describe the candidate...?” and examples of phrases that completed the items are “cares about people like you”, “is intelligent”, “is moral” and “is honest”. In the ANES from 1980 to 2004, and for a subsample of the ANES of 2008 (N = 1133), items were assessed on a 4-point scale, with answer options 4 = “Extremely well”, 3 = “Quite well”, 2 = “Not too well”, 1 = “Not well at all”. In order to use current network estimation software (van Borkulo et al., 2014), we dichotomized the data into two categories, one consisting of responses 1 and 2, and one consisting of responses 3 and 4. For a subsample of participants of the ANES of 2008 (N = 1133), and for all participants in the ANES of 2012, the items were assessed on a 5-point scale, with the answer options 5 = “Extremely well”, 4 = “Quite well”, 3 = “Moderately well”, 2 = “Slightly well”, 1 = “Not well at all”. Here, we assigned option 1, 2 and 3 in one category and option 4 and 5 in the other category.

Political Interest

As a proxy of attitude strength, we used an item that asked participants how interested they were in political campaigns. The exact wording of the item was: “Some people don’t pay much attention to political campaigns. How about you? Would you say that you have been... in the political campaigns so far this year?” Answer options were “very much interested”, “somewhat interested”, and not much interested”. To estimate networks for groups of individuals with differing degrees of attitude strength, we assigned participants who answered “very much interested”, “somewhat interested”, “not much interested” to high, intermediate, weak attitude strength groups, respectively. The number of participants assigned to each strength group at each election can be found in Table A1 in Appendix A.

Global Attitude Measure

In both the pre- and post-election surveys, participants rated how warm and favorable they felt toward the presidential candidate on a scale from 0 to 100, with 0 representing a very unfavorable attitude and with 100 representing a very favorable attitude toward the presidential candidate.

Voting Behavior

In the post-election survey, participants were asked which candidate they voted for. Depending on which presidential candidate the analysis focused, we scored the response as 1 when the participants stated that they voted for the given candidate and we scored the response as 0 when the participants did not vote for the given candidate (cf., Payne et al., 2010).
Analysis 1: The Relation between Attitude Strength and Network Connectivity

The purpose of Analysis 1 was to test the connectivity hypothesis. For this, we created attitude strength groups based on political interest and tested whether these groups differed in their network connectivity.

Data Analysis

Connectivity of attitude networks could only be estimated for groups and not individuals. In all the analyses reported in this paper, attitude strength groups function as the subjects in the analyses.

To estimate attitude network structures, we applied the eLasso-procedure (van Borkulo et al., 2014) to the responses on the non-behavioral evaluative reactions. In the eLasso-procedure, each variable is regressed on all other variables, while the regression function is subjected to regularization to control the size of the statistical problem (see Friedman, Hastie, & Tibshirani, 2008; Tibshirani, 1996).

For each network, the set of edges that displays the best fit to the data is selected based on the fit of the regression functions according to the Extended Bayesian Information Criterion (Chen & Chen, 2008). Parameters are then based on the regression parameters in the selected neighborhood functions (van Borkulo et al., 2014). For each strength group at each election, we estimated networks for the non-behavioral evaluative reactions toward each candidate by using this procedure, which resulted in a total of 54 estimated networks.

We used the Average Shortest Path Length (ASPL; West, 1996) as a measure of network connectivity. For every two given nodes in the network, the ASPL computes the length of the shortest path that connects the nodes and then averages these estimates. Dijkstra’s algorithm was used to calculate path lengths (Brandes, 2001; Dijkstra, 1959; Newman, 2001). Dijkstra’s algorithm minimizes the inverse of the distance between two node pairs using the weight of the edges (the absolute values of the regression parameters in the networks reported in this article). A low ASPL indicates high connectivity, while a high ASPL indicates low connectivity.

We fitted a general linear model with the attitude strength groups as factor, the ASPL as dependent variable, and the number of nodes in the network as covariance to control for network size. In follow-up analyses, we also included sample size and the mean variance of the variables in the networks as covariates to make sure that our results were not affected by these factors. For pairwise comparisons, we used Tukey’s test that corrects p-values for multiple testing.

The vast majority of missing values was caused by participants answering “Don’t know” on items tapping evaluative reactions. We omitted variables that had more than 10% missing values to decrease the number of participants who had to be excluded, as we applied casewise deletion to cases with missing values. The numbers of excluded participants and the omitted variables can be found in Table A1 and Table A3 in Appendix A, respectively.

Results and Discussion

Analyses of attitude stability, impact on behavior, and extremity confirmed the validity of our categorization of participants into attitude strength groups, as attitude strength groups differed in the expected directions on these three indicators of attitude strength (see Appendix B). The hypothesis that attitude strength and connectivity of attitude networks are positively related was unequivocally supported. Figure 2 shows that the ordering of the three networks was in the predicted direction for 14 out of 18 comparisons. The networks of the high attitude strength groups had a below mean ASPL in all 18 comparisons made, while the networks of the low attitude strength groups had an above mean ASPL in all but one of the cases. Note that some of the low strength networks (Mondale 1984, Bush1988, Kerry 2004) were not fully connected (i.e. not all nodes were directly or indirectly connected), which leads to infinitely large shortest path lengths between disconnected nodes. To be able to still enter such networks into the analysis, we set infinitely large shortest path lengths to the highest shortest path length in the same network that was a real number. Note that this technique results in overestimation rather than underestimation of a network’s connectivity, which implies that this technique is conservative with respect to the focal hypothesis (i.e., leads to stronger connectivity estimates in low attitude strength groups).

The fitted linear model (including the number of nodes as a covariate) showed a significant effect of the attitude strength groups on the ASPL of the networks, $F(2, 50) = 17.59, p < .001, \eta^2_p = .41$. All groups differed significantly from each other in the expected direction and these differences were marked by high effect sizes. The mean ASPL of the intermediate strength groups ($M = 2.07$) was lower than the mean ASPL of the low strength groups ($M = 2.44$), $t(50) = 3.43, p = .004, 95\% CI [0.16; 0.58], d = 1.62$, indicating that the networks of the intermediate strength groups had a higher connectivity than the networks of the low strength groups. The mean ASPL of the high strength groups ($M = 1.80$) was lower than the mean ASPL of the intermediate strength groups, $t(50) = 2.48, p = .044, 95\% CI [0.06; 0.48], d = 1.17$, indicating that the networks of the high strength groups had a higher connectivity than the networks of the intermediate strength groups. The mean ASPL of the high strength groups was lower than the mean ASPL of the low attitude strength groups, $t(50) = 5.91, p < .001, 95\% CI [0.43; 0.85], d = 2.78$, indicating that the

3 We did not include voting behavior in the estimation of the attitude networks in this analysis because we wanted to use predictability of voting behavior as an attitude strength check. Including voting behavior in the attitude network would result in networks being more densely connected when the evaluative reactions strongly predict the voting behavior because the weights between the evaluative reactions and voting behavior are necessarily stronger when the non-behavioral evaluative reactions predict voting behavior. This would make using predictability of voting behavior invalid as an attitude strength check.

4 We also ran the analyses with inclusion of all variables, imputed missing values randomly with either 0 or 1 or scored “Don’t know” as a middle point of the scale and estimated networks using polychoric correlations. The results of these analyses mirrored the results reported in this paper.
Figure 2: The barplot shows the standardized ASPL (number of standard deviations above or below mean for each set of attitude strength groups) for each candidate at each year and for each strength group. Red (blue) [green] bars represent low (intermediate) [high] strength groups. Two representative networks of the low (high) strength groups are shown above (below) the barplot. The left (right) networks represent attitude networks toward Barack Obama (George W. Bush) in 2008 (2004). Nodes represent evaluative reactions (see Table A2 in Appendix A for list of the complete wording of the items), green lines represent positive connections, red lines represent negative connections, and thickness of an edge represents the strength of the connection. Closely connected nodes are placed near each other (Fruchterman & Reingold, 1991). All networks shown in this paper were constructed using the R-package qgraph (Epskamp et al., 2012).
networks of the high strength groups had a higher connectivity than the networks of the low strength groups.

To establish the robustness of our findings, we investigated whether the results were affected by the size of the sample the networks were based on and by the mean variance of the variables included in the different networks. The effect of attitude strength group on ASPL even slightly increased with the inclusion of these two covariates, \( F(2, 42) = 18.38, p < .001, \eta^2_p = .47 \). The relation between attitude strength and connectivity thus cannot be attributed to differing sample size or mean variance of the different strength groups.

Analysis 1 showed that attitude strength and connectivity of attitude networks are strongly related. The central postulate of the CAN model that strong attitudes correspond to highly connected networks was thus supported. In the following analysis, we investigated whether connectivity of attitude networks provides an explanation of differences in attitude-behavior consistency between strong and weak attitudes.

**Analysis 2: Attitude-Behavior Consistency from a Network Perspective**

The purpose of Analysis 2 was to test whether connectivity of attitude networks can explain differences in attitude-behavior consistency. To do so, we tested whether connections between non-behavioral evaluative reactions are similar to connections between behavioral and non-behavioral evaluative reactions.

**Data Analysis**

We estimated two attitude networks for each strength group at each election and for each candidate. First, similar to Analysis 1, we estimated networks including only the measures of non-behavioral evaluative reactions and calculated the mean weights of the connections within these networks (non-behavioral connection weights). Second, we estimated networks including both measures of non-behavioral evaluative reactions and the measure of voting behavior and calculated the mean weights of the connections between voting behavior and non-behavioral evaluative reactions, while excluding connections between non-behavioral evaluative reactions (behavioral/non-behavioral connection weights).

Finally, we calculated the correlation between the non-behavioral connection weights and the behavioral/non-behavioral connection weights of all 54 pairs of networks.

Only participants, who voted for president, were included in the analysis and missing values were treated in the same way as in Analysis 1.

**Results and Discussion**

The correlation between non-behavioral connection weights and behavioral/non-behavioral connection weights was significant and of very high magnitude (see Figure 3), \( r = .82, p < .001. \) Also, when controlling for sample size and network size, this correlation decreases only slightly, \( r = .75, p < .001 \). This indicates that the strength of the connections between voting behavior and the non-behavioral evaluative reactions is similar to the strength of the connections between only the non-behavioral evaluative reactions.

Analysis 2 showed that behavior toward an attitude object is consistent with other evaluative reactions in a similar way as non-behavioral evaluative reactions are consistent with each other. This finding provides a simple explanation for why strong attitudes have strong impact on behavior, while weak attitudes do not: As all other evaluative reactions, behavioral evaluative reactions are more highly connected to other evaluative reactions in strong attitudes than in weak attitudes.

**General Discussion**

In this paper, we applied network analysis to the archival data of the ANES 1980–2012. By focusing on presidential attitudes, we investigated the central postulate of the Causal Attitude Network (CAN) model that strong attitudes correspond to highly connected attitude networks. This hypothesis was strongly supported. We also investigated whether the attitude strength/network connectivity relation extends to the connections between behavioral evaluative reactions (e.g., voting behavior) and non-behavioral evaluative reactions (i.e., beliefs and feelings). We showed that the strength of the connections between non-behavioral evaluative reactions predicted the strength of connections between behavioral evaluative reactions and non-behavioral evaluative reactions with high accuracy. Non-behavioral evaluative reactions are connected to non-behavioral evaluative reactions in a similar fashion as non-behavioral reactions are connected to each other. The reason that strong attitudes are better predictors of behavior might thus be that behavior is pressured to be consistent with beliefs and feelings to a larger extent in strong attitudes than in weak attitudes.

**Limitations**

While using archival data from the ANES for our analyses has several advantages (e.g., large and representative sample sizes), it also has some drawbacks. The measure used to assign participants to attitude strength groups was an indirect indicator of attitude strength and it would also have been more beneficial to have several measures tapping attitude strength. However, our analyses on attitude stability, attitude-behavior congruence, and attitude extremity clearly showed that the groups differed in their attitude strength in the expected way.

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5 The reason for analyzing weights instead of shortest path lengths was that direct weights between voting behavior and non-behavioral evaluative reactions are independent of the connections between only the non-behavioral evaluative reactions. Correlating shortest path lengths would probably lead to an artificially high correlation.

6 To control for differences in absolute value between the non-behavioral connection weights and behavioral/non-behavioral connection weights, we also calculated the intraclass-correlation based on a one-way fixed effects ANOVA (Shrout & Fleiss, 1979). The intraclass correlation between the different weights also indicated that they were highly similar, \( ICC = .67, F(53, 54) = 5.10, p < .001 \).
Behavioral/non-behavioral connection weights

Figure 3: Scatterplot of the relation between the non-behavioral connection weights and the behavioral/non-behavioral connection weights (excluding weights between non-behavioral evaluative reactions). Red squares (blue circles) [green triangles] represent low (intermediate) [high] strength groups. The networks below the scatterplot are an illustration of how the estimates of the behavioral/non-behavioral connection weights (left network) and the non-behavioral connection weights (right network) are derived. Only solid edges were taken into account for the estimations of the weights.

The generalizability of our results is somewhat limited as we only focused on attitudes toward presidential candidates. Whether the obtained results also hold for other attitude objects is a matter of further empirical investigations on the CAN model. It might, for example, be that networks of some attitude objects are less variable in their connectivity than attitudes toward presidential candidates. Attitudes toward some attitude objects are likely to generally correspond to weakly connected attitude networks (e.g., attitude toward a detergent brand), while attitudes toward other attitude objects are likely to generally correspond to highly connected attitude networks (e.g., attitude toward one’s romantic partner).

Given that the networks we estimated were based on groups of individuals, it is not straightforward to generalize our findings to the level of the individual (e.g., Borsboom & Cramer, 2013). However, the group-based networks reported in this paper are likely to be representative of individually based networks if the groups are relatively homogenous (e.g., individuals belonging to the same group have similar network structures; van Borkulo et al., 2015). In the case of our estimations it is rather likely that groups were quite homogenous because the assignment to different attitude strength groups made the groups more homogenous and it is also likely that connections between different evaluative reactions differ more in quantity than in quality (e.g., the connection between judging a presidential candidate to be caring and judging a presidential candidate to be moral probably is positive for most individuals). Nonetheless, future research should investigate whether our findings also replicate at the individual level using extensive time-series data (e.g., Bringmann et al., 2013).

Implications and Directions for Future Research

Our findings have fundamental implications for theorizing on attitude strength and attitude-behavior consistency. Linking attitude strength to network connectivity provides a novel and promising way to derive predictions regarding the dynamics of strong attitudes. For example, conceptualizing attitude strength as network connectivity leads to the hypothesis that strong attitudes can show instances of high instability. This would be the case when the attitude network is highly connected but at the same time has to integrate a large amount of conflicting information. Referring back to our example in the introduction, such a situation would arise if Alice (who has a highly connected positive attitude toward Barack Obama) were not able to discard the information about Barack Obama’s incapacity. At some point Alice’s attitude would probably return to a stable state but as long as her attitude has not settled in a consistent state, her attitude would oscillate between being highly positive and being highly negative (cf., Cramer et al., 2016).

The here-above described dynamics also have implications for ambivalence, which is often experienced in response to political issues and candidates (e.g., Feldman & Zaller, 1992; Haddock, 2003; Meffert, Guge, & Lodge, 2004). Specifically, ambivalence has different consequences in highly connected attitude networks than in weakly connected attitude networks, because ambivalent attitudes are inherently less aligned (in an evaluative sense) than univalent attitudes. On the one hand, the extent to which an attitude is aligned or not relates to the concept of objective ambivalence: the co-occurrence of positive and negative evaluations toward an attitude object (e.g., Newby-Clark, McGregor, & Zanna, 2002; van Harreveld, van der Pligt, & de Liver, 2009). On the other hand, the extent to which an unaligned (or objectively ambivalent) attitude is high in connectivity should be related to subjective ambivalence (the discomfort resulting from conflicting evaluations). Specifically, highly connected unaligned attitudes should be related to subjective ambivalence because this kind of ambivalence is caused by the simultaneous accessibility of both evaluative components (Newby-Clark et al., 2002).
This line of reasoning also relates to the motivation of ambivalent attitude holders to reduce their ambivalence (van Harreveld et al., 2009). While an unaligned attitude network would be highly unstable if it is highly connected (i.e., subjectively ambivalent), a weakly connected attitude network can be relatively stable when it is unaligned (and remain in a dormant objective state; Dalege et al., 2016). This hypothesis might also explain why ambivalent attitudes on the one hand show mostly characteristics of weak attitudes (e.g., ambivalent attitude do not predict behavior very well; Armitage & Conner, 2000; Conner & Sparks, 2002), while ambivalent attitudes also can have a strong impact on information processing (Jonas, Diehl, & Bromer, 1997; Nordgren, van Harreveld, & van der Pligt, 2006). Given that the impact on information processing was mostly observed for ambivalent attitudes that cause subjective ambivalence (e.g., Nordgren et al., 2006; van Harreveld, Nohlen, & Schneider, 2015), it is likely that the strong impact on information processing reflects motivation to resolve the unstable state of a highly connected attitude network that is unaligned.

Conceptualizing attitude strength as network connectivity also provides hypotheses regarding effects of campaigns on attitudes, because attitude change within strongly and weakly connected attitude networks is probably governed by qualitatively different dynamics (Dalege et al., 2016). Change in weakly connected attitude networks takes place on a continuum that ranges from a configuration in which all evaluative reactions are negative, to a configuration in which all evaluative reactions are positive, with unaligned configurations being only slightly less stable than aligned configurations. Weakly connected political attitudes would thus change smoothly during a campaign from, for example, being slightly against to being slightly for a given candidate. Change in highly connected attitude networks, however, occurs more in an all-or-none fashion, with aligned configurations being much more stable than unaligned configurations. If a campaign were to succeed in changing highly connected political attitude networks, such attitudes would change from, for example, being strongly against to being strongly for a given candidate. It is, however, more likely that campaigns succeed in changing weakly connected attitudes and it might be of advantage to identify groups of individuals with weakly connected attitude networks to focus the campaign on these groups. These dynamical characteristics of strong versus highly connected attitude networks link our work to the catastrophe model of attitudes (Latané & Nowak, 1994; van der Maas, Kolstein, & van der Pligt, 2003; Zeeman, 1976), which holds that important attitudes act like categories (i.e., attitudes can be either positive or negative), while unimportant attitudes act like dimensions (i.e., attitudes represent a continuous dimension running from positive to negative). Linking the connectivity hypothesis to the catastrophe model of attitudes leads to the prediction that important (unimportant) attitudes, or more generally strong (weak) attitudes, act like categories (dimensions) because they correspond to highly (weakly) connected networks.

Regarding the extent to which political attitudes predict behavior, the findings on connectivity in political attitude networks provide a simple explanation of why some attitudes predict (voting) behavior while others do not. It appears that political attitudes that correspond to highly connected attitude networks are better predictors of voting behavior than attitudes that correspond to weakly connected attitude networks. The reason for this is that behavioral evaluative reactions connect to other evaluative reactions in a similar way as non-evaluative reactions connect to each other. For example, Alice, who's judgments regarding Barack Obama are strongly connected will base her voting decision on her evaluative reactions, while Bob, who's judgments are less strongly connected, may base his voting decision on other factors. The reason for this is that the high connectivity of Alice’s attitude network pressures her evaluative reactions to be highly consistent.

Focusing on the connectivity of attitude networks provides novel opportunities for both predicting and influencing (voting) behavior (see also Dalege et al., 2016). Regarding behavior prediction, identifying whether individuals’ attitude networks are densely or sparsely connected can inform researchers whether it is likely or not that the measured evaluative reactions will predict subsequent behaviors. Pollsters might benefit from this because this provides a novel opportunity to estimate how likely it is that the results of a given poll will translate into election results. Regarding influencing behavior, identifying how strongly connected individuals’ attitude networks are can inform one which strategy should be taken to influence behavior. If the attitude network is weakly connected, a focus on the behavior itself (without addressing other evaluative reactions) may be a means to influence behavior effectively. If the attitude network is highly connected, however, the most promising way to influence behavior is probably to first apply strategies to decrease the connectivity of the attitude network. This might for example be accomplished by lowering the importance of the attitude. When the connectivity has decreased, it is probably easier to induce the desirable behavior. To enhance longevity of attitude change, it would be beneficial to heighten the connectivity of the attitude network after the desired behavior is induced.

Conclusion
In this paper, we provided support for the connectivity hypothesis, which holds that strong attitudes correspond to highly connected attitude networks. The connectivity hypothesis provides several novel pathways for research into the different dynamics of strong and weak attitudes inside and outside of the political context, such as instances of high instability of strong attitudes. We also showed that the connectivity hypothesis provides a simple explanation for why strong attitudes drive behavior: Strong connections in highly connected attitude networks pressure behavior toward an attitude object to align to beliefs and feelings toward the attitude object. The results of the current paper and other recent investigations into attitude networks (Dalege et al., 2016, 2017) indicate that network theory provides a framework to get closer to a comprehensive understanding of attitudes.
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Author Contributions
J.D. developed the study concept; J.D., D.B., F.v.H., and H.L.J.v.d.M contributed to the study design; J. D. performed the data analysis and interpretation under the supervision of D.B., F.v.H., and H.L.J.v.d.M.; J.D. drafted the manuscript, and D.B., F.v.H., and H.L.J.v.d.M. provided critical revisions.

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Data used in this paper is available at www.electionstudies.org. Correspondence and request for materials should be addressed to J.D. (j.dalege@uva.nl).

Competing Financial Interest
The authors declare no competing financial interests.
## Appendix A

*Table A1:* Numbers of participants assigned to the strength groups for each election and numbers of participants who had missing values on the attitude strength indicator variable. Numbers of excluded participants are shown in parentheses for the attitudes toward democratic and republican candidates, respectively.

| Election | Low strength groups | Intermediate strength groups | High strength groups | Missings indicator |
|----------|---------------------|-----------------------------|----------------------|-------------------|
| 1980     | 407 (121, 149)      | 692 (78, 100)               | 407 (50, 16)         | 49                |
| 1984     | 558 (132, 123)      | 1054 (123, 170)             | 638 (53, 81)         | 7                 |
| 1988     | 509 (139, 134)      | 960 (102, 133)              | 567 (50, 57)         | 4                 |
| 1992     | 419 (89, 60)        | 635 (101, 64)               | 304 (48, 20)         | 1                 |
| 1996     | 399 (38, 87)        | 848 (31, 100)               | 467 (22, 33)         | 0                 |
| 2000     | 396 (137, 111)      | 886 (148, 131)              | 525 (76, 44)         | 0                 |
| 2004     | 186 (71, 31)        | 528 (102, 32)               | 498 (57, 20)         | 0                 |
| 2008     | 378 (72, 87)        | 815 (89, 93)                | 1128 (88, 97)        | 1                 |
| 2012     | 895 (73, 121)       | 2460 (68, 153)              | 2554 (43, 81)        | 5                 |

*Note.* A subsample of the ANES 1996 already participated in the ANES 1992. The number of participants who completed the pre-election survey of the ANES 1996 and also participated in the ANES 1992 is 1,316.
| Abbreviation | Item                                           |
|--------------|------------------------------------------------|
| **Items tapping beliefs** |                                              |
| Cares        | “really cares about people like you”          |
| Compassionate| “is compassionate”                            |
| Decent       | “is decent”                                   |
| Dishonest    | “is dishonest”                                |
| Economic politics | “would solve our economic problems”     |
| Effective    | “gets things done”                            |
| Example      | “sets a good example”                        |
| Fair         | “is fair”                                     |
| Foreign politics | “would develop good relations with other countries” |
| Hard-working | “is hard-working”                            |
| Honest       | “is honest”                                   |
| In touch     | “is in touch with ordinary people”            |
| Inspiring    | “is inspiring”                                |
| Intelligent  | “is intelligent”                              |
| Irresolute   | “can’t make up his mind”                      |
| Kind         | “is kind”                                     |
| Knowledgeable| “is knowledgeable”                           |
| Leadership   | “would provide strong leadership”             |
| Moral        | “is moral”                                    |
| Optimistic   | “is optimistic”                               |
| Out of touch | “is out of touch with ordinary people”        |
| Religious    | “is religious”                                |
| Respectable  | “commands respect”                            |
| Understanding| “understands people like you”                 |
| Power-hungry | “is power-hungry”                             |
| Weak         | “is weak”                                     |
| **Items tapping feelings** |                                             |
| Angry        | “angry”                                       |
| Afraid       | “afraid of him”                               |
| Disgusted    | “disgusted”                                   |
| Hopeful      | “hopeful”                                     |
| Proud        | “proud”                                       |
| Sympathetic  | “sympathetic toward him”                      |
| Uneasy       | “uneasy”                                      |
Table A3: Included and excluded evaluative reactions.

| Evaluative Reaction       | Included in Data Sets | Excluded in (which candidate) |
|---------------------------|-----------------------|-------------------------------|
| **Items tapping beliefs** |                       |                               |
| Cares                     | 1984–2012             | 1984 (Mondale)                |
| Compassionate             | 1984–1996*            | 1984 (Mondale), 1988 (Dukakis & Bush) |
| Decent                    | 1984, 1988            | 1988 (Dukakis)                |
| Dishonest                 | 1980, 2000, 2004      | NA                            |
| Economic politics         | 1980                  | NA                            |
| Effective                 | 1992, 1996            | 1992 (Clinton)                |
| Example                   | 1984                  | 1984 (Mondale)                |
| Fair                      | 1984                  | 1984 (Mondale)                |
| Foreign politics          | 1980                  | NA                            |
| Hard-working              | 1984                  | 1984 (Mondale)                |
| Honest                    | 1988–1996, 2008, 2012 | 1988 (Bush), 1992 (Clinton)   |
| In touch                  | 1984                  | 1984 (Mondale)                |
| Inspiring                 | 1980, 1984, 1992, 1996| 1984 (Mondale)                |
| Intelligent               | 1984–2012*            | NA                            |
| Irresolute                | 2004                  | NA                            |
| Kind                      | 1984                  | 1984 (Mondale)                |
| Knowledgeable             | 1980–2012             | 1988 (Dukakis)                |
| Leadership                | 1980–2012             | 1984 (Mondale), 1992 (Clinton) |
| Moral                     | 1980–2012             | 1984 (Mondale), 1988 (Dukakis & Bush), 2000 (Bush) |
| Optimistic                | 2008                  | NA                            |
| Out of touch              | 2000                  | NA                            |
| Religious                 | 1984                  | 1984 (Mondale & Reagan)       |
| Respectable               | 1984                  | 1984 (Mondale)                |
| Understanding             | 1984                  | 1984 (Mondale)                |
| Power-hungry              | 1980                  | NA                            |
| Weak                      | 1980                  | 1980 (Reagan), 2000 (Bush)    |
| **Items tapping feelings**|                       |                               |
| Angry                     | 1980–2012             | 1980 (Reagan)                |
| Afraid                    | 1980–2012             | 1980 (Reagan)                |
| Disgusted                 | 1980, 1984            | NA                            |
| Hopeful                   | 1980–2012             | NA                            |
| Proud                     | 1980–2012             | NA                            |
| Sympathetic               | 1980, 1984            | NA                            |
| Uneasy                    | 1980, 1984            | NA                            |

*Note. *In 1992, these items were only assessed for Bill Clinton.*
Appendix B

Attitude Strength Checks
As a check of the validity of the attitude strength categorization, we analyzed whether the groups differed in their attitudes’ stability, impact on behavior, and extremity. To investigate stability, we calculated correlations between the global attitude measures assessed at the pre- and post-election surveys for each group with respect to each candidate in all elections (cf., Prislin, 1996). We then fitted a general linear model (with the pre-post correlation as a dependent variable and attitude strength groups as factor) to test the hypothesis that the attitudes’ stability differed between the strength groups.

To investigate impact on behavior, we calculated bivariate correlations between voting decisions and total scores on the evaluative reactions (cf., Fazio & Williams, 1986). We then fitted a general linear model (with the polychoric correlations as dependent variable and attitude strength groups as factor) to test the hypothesis that the attitudes’ impact on behavior differed between the strength groups. Participants who stated that they did not vote in the election for president were omitted from the analysis.

To investigate whether the groups’ attitudes toward the presidential candidate differed in their extremity, we calculated how strongly participants’ scores deviated from the midpoint of the global attitude measure. We then fitted a general linear model (with the average deviance as dependent variable and attitude strength group as factor) to test the hypothesis that the attitudes’ extremity differed between strength groups.

For the analyses on the global attitude measure and the voting behavior, only participants, who responded to the respective scales, were included.

Results
Group differences on all three measures were marked by high effect sizes in the expected direction (see Table B1). Interest in political campaigns was positively related to the stability of the attitudes, \(F(2, 51) = 22.00, p < .001, \eta^2 = .46\), to the attitudes’ impact on the voting decision, \(F(2, 51) = 52.7, p < .001, \eta^2 = .67\), and to the extremity of the attitudes, \(F(2, 51) = 19.68, p < .001, \eta^2 = .44\). It is thus safe to assume that the groups indeed differed in their attitude strength.

Table B1: Means and 95% confidence intervals of the strength measures for each attitude strength group.

| Group               | Stability  | Impact on Behavior | Extremity   |
|---------------------|------------|--------------------|-------------|
| Low attitude strength | .64 [.60, .68] | .53 [.46, .59]   | 19.3 [17.9, 20.7] |
| Intermediate attitude strength | .74 [.70, .77] | .66 [.61, .71]   | 21.5 [19.9, 23.2] |
| High attitude strength    | .81 [.78, .85] | .88 [.84, .93]   | 27.1 [24.6, 29.5] |