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Automatic Mental Associations Predict Future Choices of Undecided Decision-Makers

Silvia Galdi,^{1*} Luciano Arcuri,¹ Bertram Gawronski²

Common wisdom holds that choice decisions are based on conscious deliberations of the available information about choice options. On the basis of recent insights about unconscious influences on information processing, we tested whether automatic mental associations of undecided individuals bias future choices in a manner such that these choices reflect the evaluations implied by earlier automatic associations. With the use of a computer-based, speeded categorization task to assess automatic mental associations (i.e., associations that are activated unintentionally, difficult to control, and not necessarily endorsed at a conscious level) and self-report measures to assess consciously endorsed beliefs and choice preferences, automatic associations of undecided participants predicted changes in consciously reported beliefs and future choices over a period of 1 week. Conversely, for decided participants, consciously reported beliefs predicted changes in automatic associations and future choices over the same period. These results indicate that decision-makers sometimes have already made up their mind at an unconscious level, even when they consciously indicate that they are still undecided.

Imagine the following scenario: It is election time and the available voting options include two political candidates. You do not have a strong party affiliation that could guide your voting decision, and you are still undecided which of the two candidates deserves your vote. Over the next couple of weeks, you pay close attention to the media coverage of the two candidates' po-

litical campaigns and to what the candidates say about various issues you care about. After several weeks of deliberation, you finally decide that you should give your vote to candidate A rather than candidate B, and that decision is ultimately reflected in your vote on election day.

Common wisdom, as well as theorizing in psychological science, suggests that such processes of decision-making are based on a given individual's weighting of the information that is acquired during a phase of deliberation about the available options (1–3). According to this view, future choices primarily depend on (i) the particular information that is acquired, and (ii) the

decision-maker's personal weighting of that information. In this study, we investigated the differential effect of automatic mental associations and consciously held beliefs on future choices by individuals who claim to be decided versus undecided. Conceptually, automatic mental associations are defined as those associations that come to mind unintentionally, that are difficult to control once they are activated, and that may not necessarily be endorsed at a conscious level (4, 5). Such automatic associations are often contrasted with consciously held beliefs, which can be described as mental contents that an individual explicitly endorses as accurate (3, 5). The measurement of automatic associations has been advanced by the development of so-called implicit measures, most of which are based on participants' performance on computer-based, speeded categorization tasks (6, 7). These implicit measures differ from explicit measures employed to assess conscious beliefs, which are based on standard self-report or survey methodology.

We provide evidence that future choices of undecided individuals can be predicted by their current automatic mental associations, even when these individuals consciously report that they are still undecided. This case is contrasted with future choices made by decided individuals, which we expected to be guided by consciously held beliefs about choice options rather than automatic mental associations. Our hypothesis that automatic associations may predict future choices of undecided decision-makers is inspired by earlier research on political decision-making (8) and biased information processing (9, 10). The latter line of research has shown that automatic associations can bias the processing of new information in a manner that is consistent with the meaning

¹Department of Developmental Psychology and Socialization, University of Padova, Via Venezia 8, 35131 Padova, Italy.
²Department of Psychology, University of Western Ontario, Social Science Centre, London, Ontario N6A 5C2, Canada.

*To whom correspondence should be addressed. E-mail: silvia.galdi@unipd.it

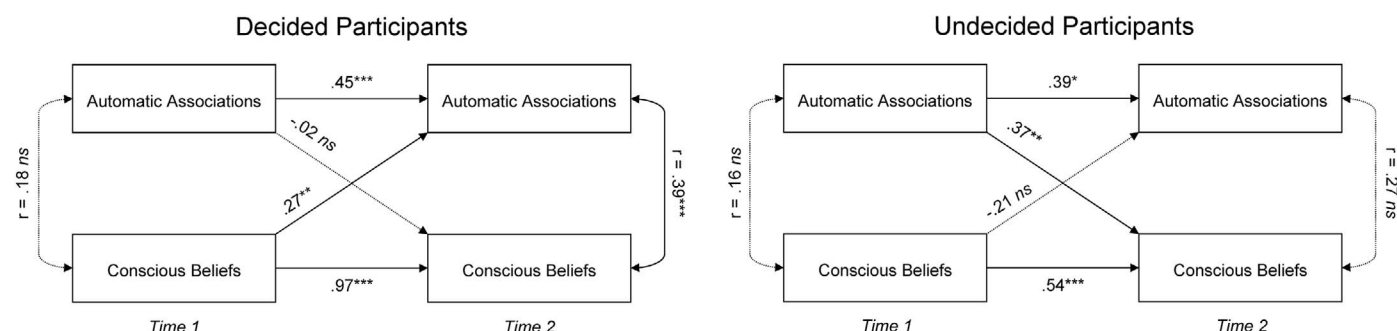


Fig. 1. Stability (horizontal arrows) and change (diagonal arrows) in automatic associations and consciously held beliefs from time 1 to time 2 (1 week apart) for participants who were indicated to be decided ($n = 96$) or undecided

($n = 33$) at time 1. The figure shows standardized beta values of simultaneous multiple regression analyses based on a two-wave-two-variable panel design (* $P < 0.05$; ** $P < 0.01$; *** $P < 0.001$; ns, not significant).

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of previously existing associations. A useful example to illustrate such effects is a study on biases in face perception (10). In this study, white participants were presented with short movie clips in which the facial expressions of black and white faces that were fully controlled for physiognomic features changed from hostile to friendly or vice versa. Depending on the particular condition, participants' task was to indicate either the offset or the onset of hostility in the target's face. Results showed that participants identified hostility earlier or for a longer period in black compared to white faces. The relative size of these effects was correlated with participants' automatic associations—but not with their conscious beliefs—regarding blacks, such that enhanced perceptions of hostile expressions in black faces increased as a function of automatic negative associations regarding blacks. Expanding on these findings, other research has shown that such biasing effects of automatic associations remain unqualified by enhanced motivation to control biased or prejudiced responses (9), suggesting that automatic associations may influence information processing outside of conscious awareness (11).

Applied to the present question, these results suggest the possibility that future decisions of undecided individuals can be predicted by measuring their current automatic associations (8). Specifically, the available results (9, 10) suggest that automatic associations could distort the processing of new information (e.g., by means of selective processing or biased interpretation), such that future decisions that are based on such distorted information will be in line with previously existing automatic associations. For instance, in our introductory example, an individual's automatic associations may be more favorable for candidate A compared to candidate B, even though this individual may not endorse a conscious preference for one candidate over the other (12, 13). Yet, these associations may nevertheless influence the processing of new information about the two candidates, such that the subsequent conclusion drawn from this information is biased in favor of candidate A over candidate B. Hence,

the individual may develop a conscious preference for candidate A over candidate B over the course of deliberating about the two options, which is rooted in the biasing influence of automatic associations on the processing of new information. From this perspective, the ultimate decision of an undecided individual may be determined, in a more or less probable sense, long before this individual consciously endorses a preference for one candidate over the other.

To test this assumption, we asked 129 residents of the city of Vicenza in Italy to complete various measures assessing their attitudes toward the enlargement of a U.S. military base in Vicenza. At the time of our data collection (October to December 2007), the enlargement plans were controversially discussed in the media, which led to a strong polarization among residents of the city. The measures included (i) a single-item question on whether participants are in favor of the enlargement, undecided, or against the enlargement (choice); (ii) a 10-item survey on participants' conscious beliefs about environmental, political, economic, and social consequences of the enlargement (conscious beliefs); and (iii) a computer-based response latency task designed to assess participants' automatic evaluative associations regarding the U.S. military base (automatic associations). The latter task was an adaptation of the Single-Category Implicit Association Test (14), in which participants had to categorize pictures of the U.S. military base, as well as positive and negative words, as quickly as possible. Automatic associations were inferred from participants' performance (i.e., response latencies, error rates) on different types of trials on this task (15). Participants completed all measures twice, with the two measurement occasions being 1 week apart.

To test the relations between automatic associations, consciously held beliefs, and future choices, we investigated the mutual relations between automatic associations and conscious beliefs for participants who were indicated to be decided versus undecided at time 1 using multiple regression and a two-wave-two-variable panel

design (Fig. 1) (16). On the basis of *t* tests to determine the statistical significance of the standardized beta weights (17), the results indicated that automatic associations were relatively stable for both undecided participants [$t(30) = 2.30, P = 0.03$] and decided participants [$t(93) = 5.12, P < 0.001$]; conscious beliefs were relatively stable for undecided participants [$t(30) = 4.08, P < 0.001$] and highly stable for decided participants [$t(93) = 33.66, P < 0.001$]. Automatic associations at time 1 significantly predicted changes in conscious beliefs over time for undecided participants [$t(30) = 2.82, P = 0.009$], but not for decided participants [$t(93) = -0.86, P = 0.39$]. Conversely, conscious beliefs at time 1 significantly predicted changes in automatic associations over time for decided participants [$t(93) = 3.07, P = 0.003$], but not for undecided participants [$t(30) = -1.23, P = 0.23$] (18). These results suggest that for undecided participants, future conscious beliefs were to a significant extent determined by their earlier automatic associations, even though these participants had consciously reported being undecided at the time of the first measurement. In contrast, for decided participants, conscious beliefs predicted changes in automatic associations, presumably reflecting a consolidation of their consciously held beliefs (5). That is, conscious beliefs may have strengthened those associations that are in line with these beliefs, such that these associations become automatic over time.

To further investigate the relations of automatic associations and conscious beliefs to future choices, we simultaneously regressed participants' choices at time 2 (in favor, undecided, against) onto automatic associations and consciously held beliefs at time 1 (Fig. 2). Results showed that for decided participants, choices at time 2 were significantly predicted by their consciously held beliefs at time 1 [$t(93) = 15.40, P < 0.001$], with automatic associations being unrelated to future choices [$t(93) = -0.15, P = 0.88$]. Conversely, for undecided participants, choices at time 2 were significantly predicted by automatic associations at time 1 [$t(30) = 2.65, P = 0.01$], with consciously held beliefs showing a positive, albeit

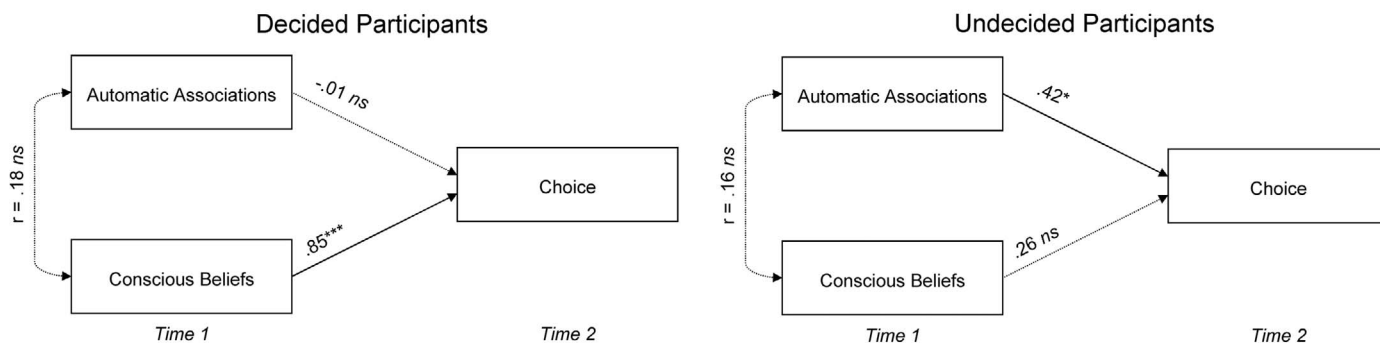


Fig. 2. Prediction of future choices (in favor, undecided, against) at time 2 by automatic associations and consciously held beliefs at time 1 (1 week apart) for participants who were indicated to be decided ($n = 96$) or un-

decided ($n = 33$) at time 1. The figure shows standardized beta values of simultaneous multiple regression analyses (* $P < 0.05$; *** $P < 0.001$; ns, not significant).

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nonsignificant, relation to future choices [$t(30) = 1.69, P = 0.10$] (19). Taken together, these results suggest that (i) conscious beliefs and future choices of undecided decision-makers are to a significant extent determined by their earlier automatic associations; (ii) such effects occur only for undecided but not for decided decision-makers, whose choices are primarily based on earlier consciously held beliefs; and (iii) conscious beliefs of decided decision-makers influence their future automatic associations, such that these associations tend to become in line with consciously held beliefs over time.

These findings have important implications for social sciences that aim at predicting future choice decisions of public interest, one of the most intriguing examples being the prediction of voting decisions. Over the past decades, political scientists have been quite successful in predicting election outcomes by means of standard survey methodology. Yet, there have been repeated cases in which tight races between political candidates made the prediction of election outcomes rather difficult. Indeed, there have been several examples in which voters were indicated to be undecided until the day of the election. The present results suggest that in such cases, the prediction of election outcomes could be enhanced by including modern measures of automatic associations, such as the one used in the present study (14) or similar measures that have been developed by social psychologists in the past decade (20–22). Even though our longitudinal design did not include a direct measure of biased information processing, earlier research suggests that automatic associations can bias the processing of new information in a manner that is consistent

with these associations (9, 10). To the extent that information about choice options is often mixed and heterogeneous, biased processing of that information can bring future choices of undecided individuals in line with their already existing automatic associations. Thus, one could say that people sometimes have already made up their mind, even though they do not know it yet.

References and Notes

1. I. Ajzen, *Organ. Behav. Hum. Decis. Process.* **50**, 179 (1991).
2. P. M. Gollwitzer, *Am. Psychol.* **54**, 493 (1999).
3. F. Strack, R. Deutsch, *Pers. Soc. Psychol. Rev.* **8**, 220 (2004).
4. J. A. Bargh, in *Handbook of Social Cognition*, R. S. Wyer, T. K. Srull, Eds. (Erlbaum, Hillsdale, NJ, 1994), pp. 1–40.
5. B. Gawronski, G. V. Bodenhausen, *Psychol. Bull.* **132**, 692 (2006).
6. R. H. Fazio, M. A. Olson, *Annu. Rev. Psychol.* **54**, 297 (2003).
7. B. Wittenbrink, N. Schwarz, *Implicit Measures of Attitudes* (Guilford, New York, 2007).
8. L. Arcuri, L. Castelli, S. Galdi, C. Zogmaister, A. Amadori, *Polit. Psychol.* **29**, 369 (2008).
9. B. Gawronski, D. Gschke, R. Banse, *Eur. J. Soc. Psychol.* **33**, 573 (2003).
10. K. Hugenberg, G. V. Bodenhausen, *Psychol. Sci.* **14**, 640 (2003).
11. B. Gawronski, W. Hofmann, C. J. Wilbur, *Conscious. Cogn.* **15**, 485 (2006).
12. W. Hofmann, B. Gawronski, T. Gschwendner, H. Le, M. Schmitt, *Pers. Soc. Psychol. Bull.* **31**, 1369 (2005).
13. W. Hofmann, T. Gschwendner, B. A. Nosek, M. Schmitt, *Eur. Rev. Soc. Psychol.* **16**, 335 (2005).
14. A. Karpinski, R. B. Steinman, *J. Pers. Soc. Psychol.* **91**, 16 (2006).
15. A. G. Greenwald, B. A. Nosek, M. R. Banaji, *J. Pers. Soc. Psychol.* **85**, 197 (2003).
16. At time 1, 96 participants were decided (32 in favor, 64 against) and 33 participants were undecided. At time 2, 9 of the formerly undecided participants were in favor of the enlargement, 14 were still undecided, and 10 were
17. The relevant requirements for an application of the employed statistical procedures were met.
18. Multiple regression moderator analyses that included decidedness as a dummy-coded moderator revealed that the impact of automatic associations at time 1 on conscious beliefs at time 2 was significantly moderated by decidedness [$t(123) = 3.43, P = 0.001$]; the moderating effect of decidedness on the impact of conscious beliefs at time 1 on automatic associations at time 2 failed to reach the conventional level of statistical significance [$t(123) = 1.64, P = 0.10$].
19. Multiple regression moderator analyses that included decidedness as a dummy-coded moderator revealed that the impact of automatic associations at time 1 on future choices at time 2 was significantly moderated by decidedness [$t(123) = 3.06, P = 0.003$]; the impact of conscious beliefs at time 1 on future choices at time 2 was not significantly moderated by decidedness [$t(123) = 0.83, P = 0.41$].
20. R. H. Fazio, J. R. Jackson, B. C. Dunton, C. J. Williams, *J. Pers. Soc. Psychol.* **69**, 1013 (1995).
21. A. G. Greenwald, D. E. McGhee, J. K. L. Schwartz, *J. Pers. Soc. Psychol.* **74**, 1464 (1998).
22. B. K. Payne, S. M. Cheng, O. Govorun, B. D. Stewart, *J. Pers. Soc. Psychol.* **89**, 277 (2005).
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