Consciousness and Cognition 37 (2015) 225–236

Contents lists available at ScienceDirect

Consciousness and Cognition

journal homepage: www.elsevier.com/locate/concog

Influencing choice without awareness

Jay A. Olson [a,c,*], Alym A. Amlani [b], Amir Raz [a,c], Ronald A. Rensink [d]

[a] Department of Psychiatry, 1033 Pine Avenue West, McGill University, Montreal, QC H3A 1A1, Canada
[b] School of Business, Kwantlen Polytechnic University, Main Building, Room 206, 12666 72 Avenue, Surrey, BC V3W 2M8, Canada
[c] The Lady Davis Institute at the SMDB Jewish General Hospital, Montreal, QC, Canada
[d] Departments of Psychology and Computer Science, University of British Columbia, 2136 West Mall, Vancouver, BC V6T 1Z4, Canada

ARTICLE INFO

Article history:
Received 18 July 2014
Available online 7 February 2015

Keywords:
Forcing
Magic
Volition
Free will
Decision making
Sense of agency
Persuasion

ABSTRACT

Forcing occurs when a magician influences the audience's decisions without their awareness. To investigate the mechanisms behind this effect, we examined several stimulus and personality predictors. In Study 1, a magician flipped through a deck of playing cards while participants were asked to choose one. Although the magician could influence the choice almost every time (98%), relatively few (9%) noticed this influence. In Study 2, participants observed rapid series of cards on a computer, with one target card shown longer than the rest. We expected people would tend to choose this card without noticing that it was shown longest. Both stimulus and personality factors predicted the choice of card, depending on whether the influence was noticed. These results show that combining real-world and laboratory research can be a powerful way to study magic and can provide new methods to study the feeling of free will.

1. Introduction

People make innumerable decisions every day. Although rational considerations often shape these decisions, subtle situational factors can also play a significant role. For example, the order of items can influence everything from food choices to donor compliance (Thaler & Sunstein, 2008). Despite such influences, however, people generally feel they have full conscious control over their choices (Wegner, 2003).

Previous studies have examined many of the subtle factors that influence decisions in everyday life. For example, moving food to a less convenient location reduces its consumption (Rozin, Scott, Dingley, Urbanek, & Kaltenbach, 2011), as does eating off of smaller (Wansink, 2007) or coloured plates (Bruno, Martani, Corsini, & Oleari, 2013). Even simply being asked to memorise a long number makes one more likely to choose cake over salad (Shiv & Fedorikhin, 2011). Although these situational factors reliably influence behaviour, most people disregard them and instead claim to have made the decision freely (e.g., Wansink & Sobal, 2007).

To study this feeling of free choice in the presence of an objective influence, one needs a method to influence decisions in a powerful yet subtle way. Magic offers one such possibility – *forcing* – which occurs when the magician influences the decisions made by the audience, without their awareness (Kelley, 1980; Kuhn, Amlani, & Rensink, 2008). For example, 'pick a card' tricks often depend on the audience feeling that they have a free choice of card, although in reality the magician controls this decision.

* Corresponding author at: Duff Medical Building, Room 103, 3775 University Street, McGill University, Montreal, QC H3A 2B4, Canada.
E-mail address: jay.olson@mail.mcgill.ca (J.A. Olson).

http://dx.doi.org/10.1016/j.concog.2015.01.004
1053-8100/

Magicians commonly use two types of forcing. *Physical* forcing involves manipulating an object to make particular outcomes more probable. For instance, spreading a deck of cards in a certain way can make spectators more likely to choose a card in the middle rather than in other positions. In contrast, *mental* forcing exploits psychological tendencies. For example, asking someone to choose any tool or any playing card tends to bring predictable candidates to mind, such as a hammer or the Ace of Spades (Banachek, 2000; Olson, Amlani, & Rensink, 2012).

Despite the magician's influence, spectators generally feel that they have a completely free choice. In other words, they can have subjective free choice without objective free choice. Although many scientists and philosophers have examined objective free choice (e.g., Libet, Gleason, Wright, & Pearl, 1983), relatively few have studied its subjective counterpart (Filevich et al., 2013; Wegner, 2003). Here we examine the subjective feeling of free choice in conditions where forcing has imposed constraints on selection.

Forcing in magic can be more precisely defined as increasing the probability of a particular outcome of a decision, without one's awareness of the influence. It differs from social persuasion, which is usually less discreet; a salesperson, say, can be quite overt when persuading someone to buy a product. It also differs from the use of *nudges* (Thaler & Sunstein, 2008) which attempt to shape decisions while maintaining objectively free choice.

The present study examines forcing in the context of the *visual riffle force*, in which the magician flips through a deck while the spectator visually selects one of the cards. Using a combination of physical and psychological forcing that we call *salience forcing*, the magician makes one card more salient than the rest which then causes the spectator to choose it.

One previous study has tested salience forcing (Shalom et al., 2013). A magician performed a visual riffle force and showed one card longer than each of the rest; about half (45%) of participants chose that card. In a second condition, participants watched videos of a magician riffling cards and were asked to choose a card from each video. People tended to choose the cards that were presented the longest (21%) or were in the last position of the series (15%). The present study extends these findings to determine which factors explain salience forcing.

Our investigation proceeds in two stages. Study 1 tests salience forcing in an environment intermediate between the stage and the laboratory. Study 2 examines a more abstract and controllable version of this method in a conventional laboratory. Together, these studies combine the realism of performance with the power of controlled experiment to explore the mechanisms underlying subjective free choice in the presence of objective influences.

2. Study 1: salience forcing in an intermediate environment

In a magic performance, many situational factors influence spectators, such as the personality of the magician, expectations created by the setup, and pressures to conform (e.g., Demacheva, Ladouceur, Steinberg, Pogossova, & Raz, 2012; Kuhn & Martinez, 2012). Thus, if an effect fails to occur in the laboratory, it is difficult to tell whether the failure was due to some characteristic of the experiment or to these situational factors. By testing the effect in an intermediate environment, we could minimise contextual factors like expectations and pressures while still reproducing the salience forcing that magicians use on stage.

2.1. Methods

A professional magician (co-author J.O.) approached student-aged individuals or small groups on university campuses and on the streets of Vancouver, Canada. He asked them if they would like to participate in a brief psychology study. A total of 119 were approached; all but one participated.

The magician took out a deck of Bicycle Playing Cards (United States Playing Card Company, Erlanger, KY). He spread the cards and ensured that the participant knew the names of the different suits (i.e., Spades, Hearts, Clubs, and Diamonds). The magician then asked the participant to choose a card by glancing at one as he flipped through the deck. He raised the deck to just under the participant's eye level and riffled through it (see Fig. 1). The entire riffle took around half a second. One of the cards – the *target card* – was intentionally shown longer than the rest; it was likely the only card that was clearly visible. In each trial, the target card was either the Two of Clubs, Ten of Clubs, or Ten of Hearts. None of these cards were extreme on any of their perceptual or cognitive properties such as visibility or memorability (Olson et al., 2012); thus, any effect would likely be due to the duration of their presentation. The magician then asked the following questions, waiting for each answer before moving on to the next:

1. Which card did you choose?
2. Did you feel that you had a free choice of any card, or did you feel that I influenced you to choose any particular card?
3. [For the last 64 participants:] Why did you choose that card?

The magician then revealed the selected card in an unexpected location (e.g., in his pocket) and subsequently debriefed the participant.

To reduce confusion, the deck never contained the target's *pair card*, the card of the same value and colour. When the Ten of Hearts was the target, for example, the deck lacked the Ten of Diamonds. Thus, we could count those who chose the pair card (8%) as having chosen the target, since presumably that was their intention.

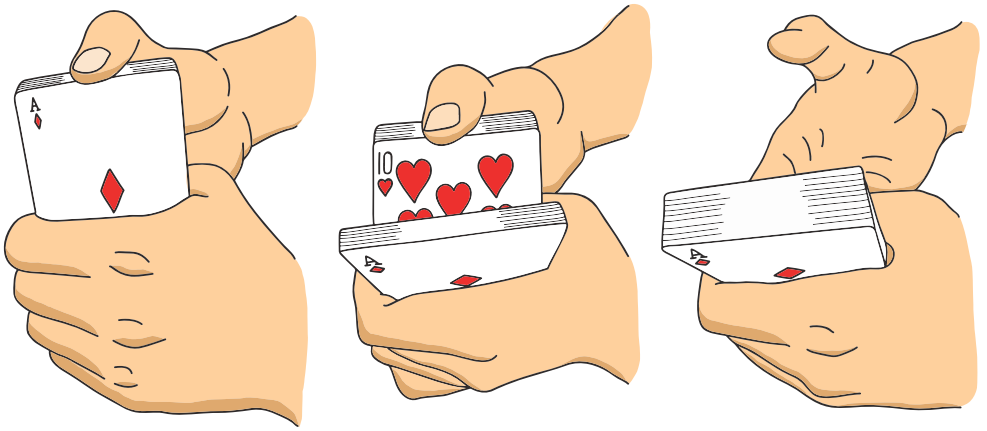

Fig. 1. The magician riffled through a deck while the participant visually chose a card. The cards were each visible for different lengths of time, but the target card (here, the Ten of Hearts) was shown longer than the rest.

For each day (of ten) of data collection, the first participant was considered a practice trial and was excluded. The magician made a mechanical error on three of the trials so these were excluded as well. The analyses were thus run on a set of 105 trials.

2.2. Results and discussion

Participants told the magician (a) which card they chose, (b) whether it felt like a free choice, and (c) why they selected that card.

2.2.1. Chosen card

Almost all (98% [93%, 100%][1]) participants chose the target card. The two who chose other cards were run on the first day of data collection and could reflect an unnoticed mechanical error by the magician. This forcing rate exceeded one previously reported (45%; Shalom et al., 2013) likely because we showed the target card for a relatively long duration.

2.2.2. Subjective free choice

Of the 103 who chose the target card, the large majority (91% [82%, 95%]) reported feeling that they had a free choice. Of the 10 who did not, 2 reported feeling suspicious about the task without necessarily noticing the influence. One participant, for example, said the situation looked like a magic trick so she probably was being influenced.

2.2.3. Reasons for choice

Of the participants who chose the target, 61 were asked why they chose that card. Most (52%, $n = 32$) reported that they had no reason. Of the remainder, 38% ($n = 11$) reported that they clearly saw only one card and 28% ($n = 8$) said that their card "stood out". The remaining 34% ($n = 10$) provided *confabulations*, inaccurate post hoc attempts to explain their decisions (cf. Johansson, Hall, Sikstrom, Olsson, & Sikstrm, 2005). Most ($n = 8$) said they chose the card because it had a bright colour; this explanation was given even when the card was black. One participant claimed that she chose the target (the Ten of Hearts) because "hearts are a common symbol and the red stood out". Another claimed to choose that card because she had been thinking of hearts before the trick began. Note that all of the target cards had only average levels of memorability and visibility.

In short, the vast majority chose the target card without being aware of the salience forcing, and many confabulated their explanation of why they chose that card.

2.2.4. Limitations

Our methodology had two potential limitations. First, the measurement of participants' awareness of the influence may have been somewhat unreliable. For example, some participants could have been unaware of the influence until they were asked about it. Still, given the low noticing rate, this could only have occurred for a small minority of participants; moreover, this would only cause an underestimate of the effectiveness of the force.

Second, demand characteristics may have led participants to comply with the researcher. During debriefing, several participants reported feeling nervous and pressured throughout the experiment which may have increased compliance. We tried to reduce compliance in several conditions by changing the experimenter's behaviour, appearance, or procedure.

[1] Square brackets throughout denote 95% confidence intervals (see Cumming, 2014).

Yet, whether the magician acted in a dominant or relaxed manner, whether he dressed more formally or casually, and whether he or a research assistant asked the questions, the influence and subjective free choice rates remained high.

In summary, this study confirms what magicians have long known: the subjective impression of a free choice can dramatically dissociate from reality. To further examine the factors involved, Study 2 attempted to reproduce this effect in a more controlled manner.

3. Study 2: salience forcing in the laboratory

Having established the reliability of forcing in an intermediate environment, we next studied it under more controlled laboratory conditions. In particular, we wanted to determine the extent to which stimulus and personality factors may affect it. For example, playing cards have a range of perceptual and cognitive characteristics. Some of these – such as the visibility of a card – may affect how often it is chosen. To measure visibility, participants searched for a given card as a series of them appeared on a computer; we averaged then compared the results for each card (Olson et al., 2012). For instance, the Ace of Spades was the easiest to perceive and remember in a rapid series, with its unique pip (spot) and markings. We used similar procedures to measure other characteristics of cards. Here we investigate five of them:

- *Visibility*, how easily a card is discriminated from others in a rapid display.
- *Visibility bias*, the bias in declaring the card absent in a detection task, wherein a higher bias means more likely to declare the card absent (this is independent of how visible the card is; cf. Green & Swets, 1966).
- *Memorability*, how easily the card is remembered in a slower display.
- *Memorability bias*, the bias in declaring the card absent when remembering (this is independent of memorability); and
- *Likeability*, how often the card is preferred relative to others.

We predicted that cards with higher visibility and memorability (d' in Signal Detection Theory) would be chosen more often, since they would have a greater effect on perception and memory. We also predicted that cards with lower bias (c) would be chosen more often, since they have a lower threshold for being declared present.

We also examined personality characteristics. Some magicians believe certain people are more susceptible to magic tricks involving forcing, such as opposite-sex participants or those in a particular age range. We examined two personality measures that may predict salience forcing:

- *Locus of control* is the amount of control one believes to have over one's life (Duttweiler, 1984). People with an internal locus tend to believe in responsibility and autonomy; those with an external locus tend to believe in luck and fate.
- *Transliminality* is the threshold for stimuli to enter conscious awareness (Lange, Thalbourne, Houran, & Storm, 2000). People with higher transliminality respond to more subtle internal and external stimuli, such as fleeting thoughts or faint smells, near the threshold of conscious detection. Transliminality measures openness to experience, warmth, absorption, and magical beliefs.

We predicted that people with a more external locus of control would be easier to influence. Presumably those who *feel* that external factors control their lives would more likely let such factors influence their decisions. We also predicted those with high transliminality would be more sensitive to the target and thus more easily influenced. A previous study found that people with high transliminality were better able to identify briefly-presented playing cards (Crawley, French, & Yesson, 2002); since we had similar stimuli and procedures we expected a similar effect.

3.1. Methods

We recreated a simple version of the visual riffle force using a series of images of cards sequentially presented on a computer. Participants were asked to watch this sequence and silently choose one of the cards then enter it at the end of the trial. Each trial contained one target card shown about three times longer than the rest. Based on the results of Study 1, we expected that participants would often choose this card without noticing that it was shown longer. At the end of the experiment, we probed whether participants were aware of this influence.

3.1.1. Participants

Fifty-two undergraduates completed the experiment for course credit or money. All had normal or corrected-to-normal vision. Nine participants did not complete all of the questionnaires in the study and so were excluded. Thus, our final sample comprised 43 participants.

These participants were most often female (70%), 23 years old (SD = 3.2), and spent most (Mdn = 75%) of their lives in Canada. They primarily spoke (74%) and wrote (65%) English, spent 5.9 h on the computer each day (SD = 3.6), and used glasses or contacts for vision correction (74%).

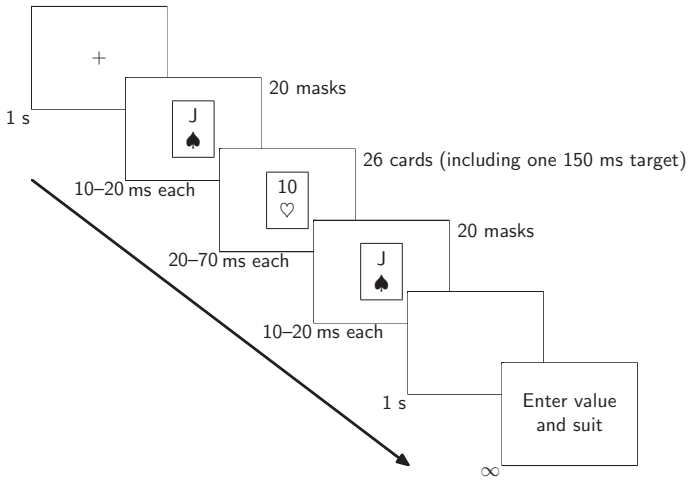

Fig. 2. Design of each trial.

3.1.2. Materials

The experiment used the same deck of cards as in Study 1, but scanned and displayed on an Apple eMac G4/700 (Cupertino, CA, USA). The computer setup resembled the one described by Olson et al. (2012). The experiment was coded in GNU Octave 3.2.3 (Eaton, Bateman, & Hauberg, 2008) with Psychtoolbox 3.0.9 (Brainard, 1997). Statistics used R 3.0.2 (R Core Team, 2014) with the ggplot2 1.0.0 (Wickham, 2009) and lme4 1.1-6 packages.

3.1.3. Procedure

Participants signed up through the participant pool to complete a task ostensibly involving telepathy. The experimenter did not explain anything about telepathy but simply told the participant that this would be explained afterwards. Neither the experimenter nor the task instructions mentioned magic. We framed the task in this way because an unpublished study found that participants were more sceptical of magic tasks than telepathy ones (O. Crofton, 2010, personal communication).

3.1.3.1. Personality measures. Next, participants filled out questionnaires measuring demographics, locus of control, and transliminality. Locus of control was measured with the Internal Control Index (Duttweiler, 1984), a 28-item paper questionnaire. An example item is: "I always like jobs where I can make my own decisions and be responsible for my own work." A higher score (maximum: 140) indicates a more internal locus; a lower score (minimum: 28) a more external one. This scale usually has fairly high internal consistency reliability (Cronbach's $\alpha = .84$; Duttweiler, 1984); it was slightly lower in our sample (.79). Participants had an average Internal Control Index of 85.31 ($SD = 10.54$).

Transliminality was measured with the Revised Transliminality Scale, a 29-item true–false paper questionnaire (Houran, Thalbourne, & Lange, 2003; Lange et al., 2000). An example item is: "I have gone through times when smells seemed stronger and more overwhelming than usual." Labelling this statement 'true' would increase the transliminality score and would suggest higher sensitivity — that more near-threshold material enters awareness. The scale has fairly high internal consistency reliability (Cronbach's $\alpha = .82$; Lange et al., 2000); it was lower in our sample (.67). Participants had an average Revised Transliminality Scale score of 6.46 ($SD = 3.11$). This measure was unrelated to the Internal Control Index ($r = -0.02$).

3.1.3.2. Behavioural measures. At the beginning of the task, the computer gave the following instructions: "You will see a series of playing cards. Choose *any* one you want. Stare at the cross at the beginning of the trial. If you don't know, guess." The participants then completed 28 trials (see Fig. 2 for an overview).

Each trial began with a 1-s fixation cross centered at where the top left pip of the playing card would appear. Ten masks consisting of random coloured squares then appeared for 20 ms each, followed by ten playing card masks for 10 ms each. The latter consisted of cards not displayed in the main series. All were presented with a 0 ms inter-stimulus interval.

A main series of 26 cards then followed. Each of the 25 non-target cards was displayed for a random duration of 20–70 ms, and the target for 150 ms.[2] The whole series (including the masks) required approximately 1.7 s. The target card appeared at a random position in the series, counter-balanced across the first and last half. It never appeared in the first or last four positions in case these were less adequately masked. The target differed each trial but each participant saw the same set of targets; trial order was balanced with a Latin square.

[2] Pilot studies found these durations effective for salience forcing on a computer, though they diverged somewhat from the durations used in Study 1.

Table 1
Stimulus factors and target cards. Each set of cards showed a high range of values on the factor.

Factor	Target cards
Visibility	K♠, 7♡, 2♣, 8♢
Visibility bias	2♠, 3♠, 6♡, 3♣
Memorability	4♡, 8♡, 9♡, A♣
Memorability bias	7♠, 8♣, J♢, K♢
Likeability	Q♠, 2♡, 2♢, 7♢
(Other target cards)	5♠, J♠, 5♡, 5♣, A♢, 3♢, 5♢, 9♢

Table 2
Common responses to post-test questionnaire items. $N = 43$.

Question	Common responses
1. During the task, when you were choosing playing cards, how did you make your choices? Did you use any strategies?	No strategy (26%); chose last card (14%); chose card that stood out (12%); stared at pip of card (9%); chose first card (9%); chose card shown longest (9%).
2. Did you notice anything during the task?	The same cards repeated each trial (23%); some cards were shown longer (5%); one card was shown longest (2%).
3. Did you feel that you had a free choice over which cards you chose?	Yes (66%)
4. Did you feel that you were being influenced to choose any particular cards?	No (52%)
5. Did you notice that any cards were shown longer than the others?	Yes (67%)
6. Each trial, one card was shown longer than all of the rest of the cards. Did you notice this?	Yes (60%)
7. Whether or not you noticed it, about how many times do you think you chose the card shown the longest? (There were 28 trials.)	$M = 9.43$ ($SD = 7.47, Mdn = 7$).

After the main series, ten cards followed by ten random-square masks provided backwards masking. After a 1 s blank screen, participants entered the value and suit of the card they chose; this became the main dependent variable.

We used 28 possible target cards, selected to create a high range of values on each stimulus factor (see Table 1). For example, for likeability, two cards (Q♠, 2♡) were highly liked and two (2♢, 7♢) were liked relatively little. (For the values of each card, see Olson et al., 2012.) Non-target cards were selected randomly in each trial and generally had intermediate values on these measures.

After 28 trials – one for each target – participants completed another questionnaire (Table 2) which probed whether they were aware that one card was shown longer than the rest. The participants classified as *aware* either spontaneously reported that one card was shown longest (Question 1 or 2) or stated that they noticed that one card was shown longest after they were asked (Question 6). We decided on this operationalisation before analysing the data (cf. Simmons, Nelson, & Simonsohn, 2011). Three participants responded ambiguously to Question 6 and so were excluded from the analyses involving awareness.

3.1.4. Analysis

We used mixed-effect logistic regression. This method assumes there is neither perfect multicollinearity nor specification error. Variance inflation factors showed little evidence of multicollinearity. The absence of specification error occurs when all and only relevant predictors are included in the model (Meyers, Gamst, & Guarino, 2006). Because this was an exploratory study, we could only model a subset of relevant factors, so some degree of specification error was present. Thus, p values are likely not trustworthy; instead, we focus primarily on effect sizes (Cumming, 2014; Kline, 2013).

3.2. Results and discussion

3.2.1. Choice of target

Overall, participants chose the target card on 30% [28%, 33%] of the 28 trials. Though reasonably high, this rate was lower than in Study 1 (98%), possibly because many of the social and situational factors central to magic tricks were absent; alternatively, the timing parameters may not have been optimal. In any event, among target cards in our sample, people chose Aces the most and the Eight of Diamonds the least (Fig. 3). Relatedly, Aces are among the most visible, memorable, and accessible cards, and the Eight of Diamonds is among the least (Olson et al., 2012).

3.2.2. Awareness of influence

After 28 trials, 40% [23%, 77%] of participants still reported being unaware that the target was shown the longest in each trial (cf. Question 6 of Table 2). Personality measures poorly predicted awareness (Table 3). Aware participants had an

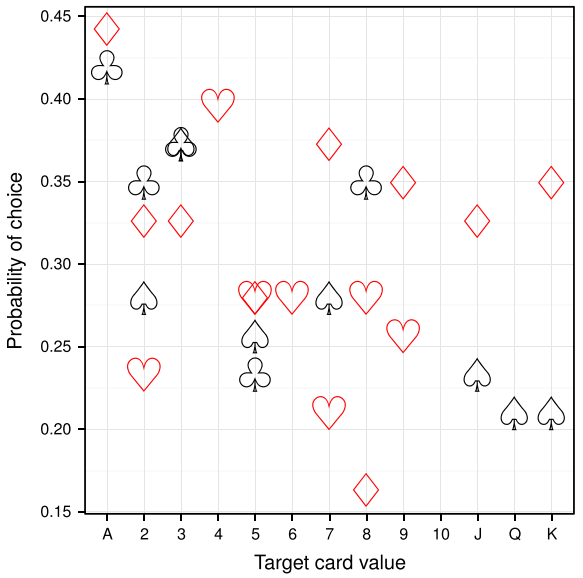

Fig. 3. Probability of choosing each of the 28 target cards tested. Based on 1204 trials with each card equally tested. Each data point averages 43 trials.

Table 3
Personality predictors of noticing. *B* is the change in odds for each unit increase in the predictor and OR is the odds ratio. $N = 40$ participants.

	B	SE	*z*	*p*	OR
(Model y-intercept)	4.747	2.947	1.611	0.107	
Locus of control	−0.051	0.032	−1.577	0.115	0.951
Transliminality	0.023	0.103	0.221	0.825	1.023

Internal Control Index of 84.07 ± 1.91 (mean ± standard error [SE]) and the unaware ones 89.29 ± 2.56; the groups in our sample therefore differed by 0.5 standard deviations (d_{unb}; see Cumming, 2014). Transliminality had almost no effect (Table 3).

3.2.3. Choice of target by aware participants

Aware participants – those who noticed one card was shown longest – chose the target card on 23% [19%, 26%] of the trials. Their choice was based on stimulus characteristics but not personality measures (Table 4). For each unit increase in visibility and visibility bias, the odds of choosing the target card increased by a factor of 5.54 and 7.82, respectively. We did not expect the latter result: people were more likely to choose target cards that had a higher bias – that is, those more likely to be declared *absent* in a detection task. This effect applied only when aware participants (but not unaware ones) chose target cards (not other cards). Since target cards with a high visibility bias are difficult to detect, when they *are* detected, they may become more salient or visible than average. If this conscious perception influences choice, it would show a particularly strong effect for these high visibility bias cards. This effect did not occur for non-target cards perhaps simply because they were not displayed long enough to generate such high levels of visibility.

For each unit increase in memorability, the odds of choosing the target increased by a factor of 4.77. In contrast, memorability bias had relatively little predictive power (odds ratio [OR] = 1.26). Likeability weakly predicted choice:

Table 4
Predictors of target card choice among aware participants. $N = 672$ trials.

	B	SE	*z*	*p*	OR
(Model y-intercept)	−3.387	2.473	−1.369	0.171	
Visibility	1.713	0.832	2.058	0.04	5.544
Visibility bias	2.057	0.917	2.244	0.025	7.823
Memorability	1.563	0.649	2.409	0.016	4.772
Memorability bias	0.23	0.688	0.334	0.738	1.259
Likeability	−2.222	1.235	−1.799	0.072	0.108
Locus of control	0.008	0.025	0.322	0.747	1.008
Transliminality	−0.122	0.086	−1.42	0.155	0.885
Trial	0.017	0.011	1.493	0.135	1.017

Table 5
Predictors of target card choice among unaware participants. $N = 448$ trials.

	B	SE	*z*	*p*	OR
(Model y-intercept)	5.262	2.991	1.759	0.079	
Visibility	−1.222	1.08	−1.132	0.258	0.295
Visibility bias	−0.938	1.153	−0.813	0.416	0.391
Memorability	0.417	0.817	0.511	0.609	1.518
Memorability bias	0.119	0.878	0.136	0.892	1.127
Likeability	−1.709	1.578	−1.083	0.279	0.181
Locus of control	−0.044	0.026	−1.7	0.089	0.957
Transliminality	−0.157	0.075	−2.086	0.037	0.854
Trial	0.04	0.015	2.722	0.006	1.041

unexpectedly, people seemed to choose less likeable cards. For a full unit increase in likeability, the odds of choosing the target decreased by a factor of 0.11, controlling for other predictors. There were no large learning or fatigue effects (see Trial in Table 4).

3.2.4. Choice of target by unaware participants

Unaware participants chose the target card on 30% [27%, 33%] of the trials, slightly (7%) higher than the aware participants. Unlike the situation for the aware participants, choice was now better predicted by personality than stimulus factors (Table 5). In our sample, people with a more external locus of control tended to choose the target card slightly more. Restated, those who believed that external factors influence their lives were easier to influence. A one-unit increase in the Internal Control Index decreased the odds of choosing the target by a factor of 0.96. However, this effect was small and may be unreliable.

Transliminality had a stronger effect. People with a higher score (i.e., those more sensitive to faint stimuli) chose the target less often than those with a lower score. A one-unit increase in transliminality decreased the odds of choosing the target by a factor of 0.85. Perhaps those with higher transliminality could identify more of the non-target cards and so would choose these more often. Indeed, high transliminality participants seemed to choose non-target cards of shorter durations. Based on a median split, these participants chose cards shown 48.82 ± 1.21 ms (mean ± SE) compared to low transliminality participants at 53.23 ± 0.92 ms, a 0.27 standard deviation difference (d_{unb}). The probability of choosing the target card increased slightly as the trials progressed (OR = 1.04).

Importantly, then, different factors predicted target card choice depending on whether participants noticed the influence. For those who were aware, choice was predicted by stimulus factors; for those who were unaware, it was predicted by personality factors. This suggests participants may have used different strategies for choosing cards depending on their awareness. Of the aware participants, 27% reported knowingly choosing the longest card; of the unaware, none reported this strategy. This difference in strategies may explain why aware participants tended to choose cards that were more visible and memorable.

3.2.5. Choice of non-target card

When people did not choose the target card (i.e., the one presented longest), they often chose cards near the beginning or end of the trial (Fig. 4). We see the usual primacy and recency effects (Murdock, 1962); cards at the beginning and the end of the stream may also have been less adequately masked. Consistent with the tendency found for targets, people chose cards that were shown longer (Fig. 5) likely because they had more time to process these cards. In addition, perhaps stimuli shown longer had more apparent contrast (see Bloch's Law; Kahneman & Norman, 1964) and so may have had greater salience, drawing more attention.

People also seemed to preferentially choose Aces and lower number cards (Fig. 6), which are easier to perceive, remember, and verbally access (Olson et al., 2012). In particular, choice of non-target card related to memorability (Fig. 7). After removing extreme scores,[3] for each unit increase in memorability, there was a 16.32 raw frequency increase in choice (out of 842 non-target choices), $r_{46} = 0.4, p = .005$. There were no other strong relationships between choice and stimulus factors.

3.2.6. Limitations

An important – though unavoidable – limitation of this study was its operationalisation of awareness. We measured awareness primarily via the question: "Each trial, one card was shown longer than all of the rest of the cards. Did you notice this?" (cf. Question 6 of Table 2). Because noticing is a subjective activity, assessing whether people actually did notice something is difficult (Newell & Shanks, 2014). In any event, given the tendencies we have found between groups, our operationalisation may have been at least somewhat effective. Future studies may use more recent measures such as the Sense of Agency Rating Scale (Polito, Barnier, & Woody, 2013) or follow the instructions of Newell and Shanks (2014).

[3] Based on a previous analysis of atypical cards, these were the Ace of Spades, and the Ace, Queen, and King of Hearts (Olson et al., 2012).

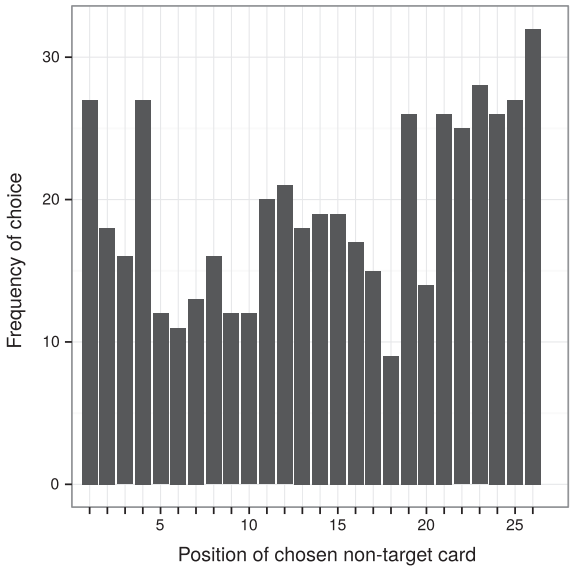

Fig. 4. Non-target cards chosen by position in stream (1–26). Based on 506 trials in which present non-targets were selected.

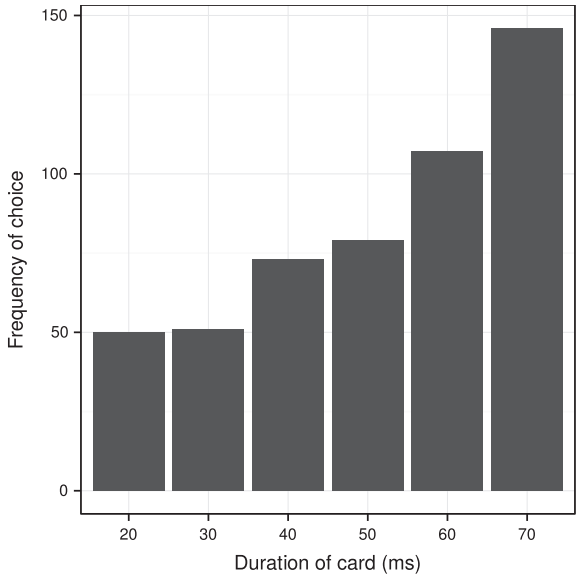

Fig. 5. Frequency of choice by non-target card duration. $N = 506$.

4. Discussion

For centuries, magicians have amazed audiences by subtly yet powerfully influencing their decisions. Here we harnessed this technique to study how people choose a particular card without awareness of an objective influence on their choice. Among other things, we discovered that stimulus and personality characteristics both predicted choice, depending on whether or not the influence was noticed. Specifically, participants aware of the influence chose visible, memorable, and unlikeable target cards, while personality factors mattered little. Conversely, for unaware participants, stimulus factors mattered little, while personality factors – in particular, transliminality – better predicted the degree of forcing. This suggests that different decision-making mechanisms may be at play for the different states of consciousness.

One of the mechanisms underlying salience forcing may be exogenous attention capture. Stimuli with particular features, such as a different colour from the background, can automatically capture attention; in some cases, this can occur without awareness (Mulckhuyse, Talsma, & Theeuwes, 2010). In our experiment, perhaps the longer duration of the target card captured attention automatically, so people chose that card without knowing why.

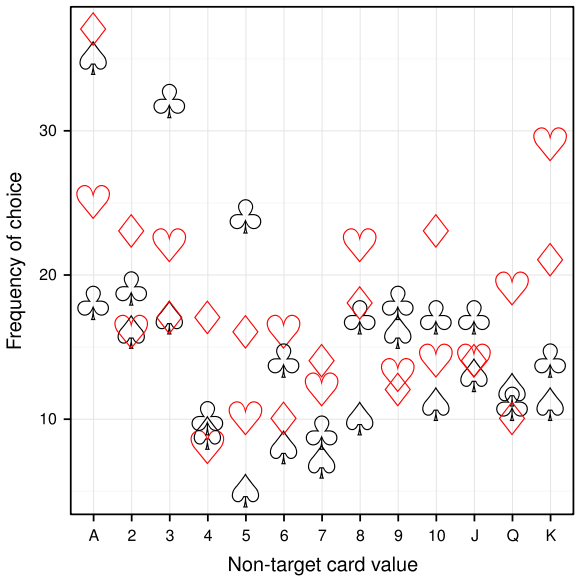

Fig. 6. Non-target cards chosen. $N = 842$.

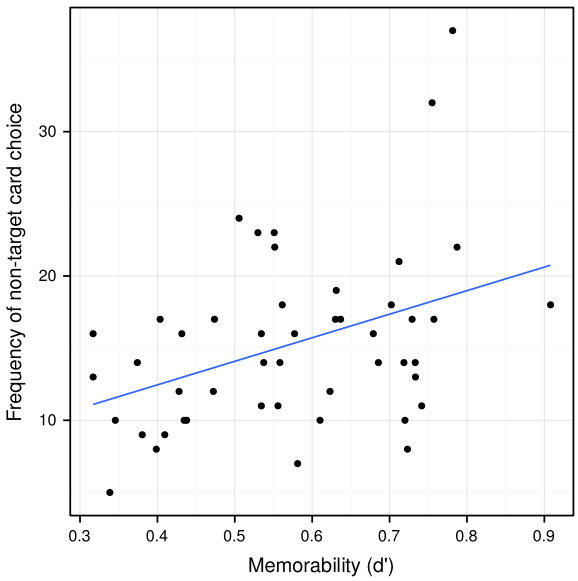

Fig. 7. Frequency of choosing each non-target card by memorability, $r_{46} = .4,\ p = .005$.

Salience forcing is only one method of dozens that magicians use to influence audiences. Exploring such methods could reveal new ways to present choices or modify environments in order to encourage better decision-making (Thaler & Sunstein, 2008; Wansink & Sobal, 2007). Beyond its practical benefit, understanding forcing and the impression of a free choice may also help the study of the sense of agency and decision-making. The present studies demonstrate that people can be influenced by external forces yet feel their choice is free. In other situations, such as when using a Ouija board (Gauchou, Rensink, & Fels, 2012), the converse holds: people are not influenced by such forces, yet believe their choice is constrained. In a sense, this shows a double dissociation between objective and subjective free choice. Such a dissociation may relate to distortions in the sense of agency seen in disorders of mental control, such as schizophrenia and alien hand syndrome (cf. Haggard, Martin, Taylor-Clarke, Jeannerod, & Franck, 2003). Experimentally distorting the sense of agency in the more accessible non-clinical population could also lead to insights about these symptoms (Olson, Landry, Appourchaux, & Raz, in progress).

Forcing may also shed light on the nature of higher-level cognition, such as the ability of humans to account for the decisions they have made. Especially in our first study, participants that were influenced often created confabulations that had little to do with the actual constraints on their behaviour. Forcing could thus provide a reliable way to examine this phenomenon. It might also help with related effects, such as the introspective illusion, in which people overestimate the accuracy of their thoughts (Nisbett & Wilson, 1977; Pronin & Kugler, 2007).

As a magician, precise knowledge of forcing could improve performances. Some types of forcing – especially psychological forcing – have relatively low success rates (e.g., Shalom et al., 2013). Greater success might be obtained by using cards that are more often chosen (cf. Fig. 6) or participants who are more susceptible. Currently, magicians tend to choose target cards and participants arbitrarily or based on heuristics which have yet to be formally tested. Just as the careful study of playing cards can refine magicians' intuitions (Olson et al., 2012), the careful study of forcing may likewise help magicians improve the effectiveness of their magic tricks.

Of interest to both magicians and scientists, we recommend researchers also focus on the situational factors that influence the effectiveness of forcing. As we have seen, stimulus and personality factors have limited effect; other factors – in particular, situational ones – may have a larger influence. For example, when offering a choice of card, magicians often pressure spectators to choose one quickly and may touch or rush participants to increase compliance (e.g., Kleinke, 1977). Indeed, some magicians believe the spectator's personality is largely irrelevant to forcing: a skilled performer should be able to make almost anyone conform on stage.

In any event, the present studies outline a methodology for analysing magic effects in a controlled environment. The ideal methodology may be to start with an in-person magic trick (Study 1), followed by a video representation of the same effect, and finally a reproduction using stimuli on a computer (Study 2). Such a progression could isolate the factors that enable the trick while retaining much of its power.

To make it easier for researchers to study forcing and the factors that influence choice, we have made our data available online at http://osf.io/hwesj/. By doing so, we hope to help researchers participate in this growing field. In particular, we hope that similar methodologies which combine the realism of the performing environment with the control of the laboratory will foster collaboration between the art of magic and the science of psychology.

Acknowledgments

We would like to thank Chris Port and Ramyar Sigarchy for their help running the experiments, Kevin Ho for his comments on earlier versions of the manuscript, and Tony Barnhart, Vince DiLollo, Craig Fox, Thomas Fraps, Gustav Kuhn, Mathieu Landry, Hakwan Lau, Zenon Pylyshyn, Brian Scholl, Shin Shimojo, Daniel Simons, Teller, and Julia Yudova for various ideas and feedback. The hand illustration (Fig. 1) was drawn by Eli Sheiner. Funding was provided by the Natural Sciences and Engineering Research Council of Canada (NSERC), via a scholarship to J.O. and grants to R.R.

References

Banachek (2000). *Psychological subtleties*. Houston, TX: Magic Inspirations.

Brainard, D. H. (1997). The psychophysics toolbox. *Spatial Vision, 10*, 433–436. http://dx.doi.org/10.1163/156856897X00357.

Bruno, N., Martani, M., Corsini, C., & Oleari, C. (2013). The effect of the color red on consuming food does not depend on achromatic (Michelson) contrast and extends to rubbing cream on the skin. *Appetite, 71*, 307–313. http://dx.doi.org/10.1016/j.appet.2013.08.012.

Crawley, S. E., French, C. C., & Yesson, S. A. (2002). Evidence for transliminality from a subliminal card-guessing task. *Perception, 31*(7), 887–892.

Cumming, G. (2014). The new statistics: Why and how. *Psychological Science, 25*(1), 7–29. http://dx.doi.org/10.1177/0956797613504966.

Demacheva, I., Ladouceur, M., Steinberg, E., Pogossova, G., & Raz, A. (2012). The applied cognitive psychology of attention: A step closer to understanding magic tricks. *Applied Cognitive Psychology, 1*, 541–549. http://dx.doi.org/10.1002/acp.2825.

Duttweiler, P. C. (1984). The Internal Control Index: A newly developed measure of locus of control. *Educational and Psychological Measurement, 44*(2), 209–221. http://dx.doi.org/10.1177/0013164484442004.

Eaton, J.W., Bateman, D., Hauberg, S., (2008). GNU Octave Manual Version 3. Network Theory Limited.

Filevich, E., Vanneste, P., Brass, M., Fias, W., Haggard, P., & Kühn, S. (2013). Brain correlates of subjective freedom of choice. *Consciousness and Cognition, 22*(4), 1271–1284. http://dx.doi.org/10.1016/j.concog.2013.08.011.

Gauchou, H. L., Rensink, R. A., & Fels, S. (2012). Expression of nonconscious knowledge via ideomotor actions. *Consciousness and Cognition, 21*(2), 976–982. http://dx.doi.org/10.1016/j.concog.2012.01.016.

Green, D. M., & Swets, J. A. (1966). *Signal detection theory and psychophysics* (Vol. 1). Wiley. doi:10.1901/jeab.1969.12-475.

Haggard, P., Martin, F., Taylor-Clarke, M., Jeannerod, M., & Franck, N. (2003). Awareness of action in schizophrenia. *Neuroreport, 14*(7), 1081–1085. http://dx.doi.org/10.1097/01.wnr.0000073684.00308.c0.

Houran, J., Thalbourne, M. A., & Lange, R. (2003). Methodological note: Erratum and comment on the use of the Revised Transliminality Scale. *Consciousness and Cognition, 12*(1), 140–144.

Johansson, P., Hall, L., Sikstrom, S., Olsson, A., & Sikström, S. (2005). Failure to detect mismatches between intention and outcome in a simple decision task. *Science, 310*(5745), 116–119. http://dx.doi.org/10.1126/science.1111709.

Kahneman, D., & Norman, J. (1964). The time-intensity relation in visual perception as a function of observer's task. *Journal of Experimental Psychology, 68*(3), 215–220.

Kelley, H. (1980). The management of causal attributions. In D. Gurlitz (Ed.), *Perspectives on attribution research and theory* (pp. 19–35). Cambridge, MA: Ballinger Publishing Company.

Kleinke, C. L. (1977). Compliance touching to requests made by gazing and experimenters in field settings. *Journal of Experimental Social Psychology, 13*, 218–223.

Kline, R. B. (2013). *Beyond significance testing: Reforming data analysis methods in behavioral research (Second.)*. Washington, DC: American Psychological Association.

Kuhn, G., & Martinez, L. M. (2012). Misdirection – past, present, and the future. *Frontiers in Human Neuroscience, 5*. http://dx.doi.org/10.3389/fnhum.2011.00172.

Kuhn, G., Amlani, A. A., & Rensink, R. A. (2008). Towards a science of magic. *Trends in Cognitive Sciences, 12*(9), 349–354. http://dx.doi.org/10.1016/j.tics.2008.05.008.
Lange, R., Thalbourne, M. A., Houran, J., & Storm, L. (2000). The revised transliminality scale: Reliability and validity data from a Rasch top-down purification procedure. *Consciousness and Cognition, 9*(4), 591–617.
Libet, B., Gleason, C. A., Wright, E. W., & Pearl, D. K. (1983). Time of conscious intention to act in relation to onset of cerebral activity (readiness-potential). The unconscious initiation of a freely voluntary act. *Brain: A Journal of Neurology, 106*, 623–642. http://dx.doi.org/10.1093/brain/106.3.623.
Meyers, L., Gamst, G., & Guarino, A. (2006). *Applied multivariate research: Design and interpretation*. Sage Publications.
Mulckhuyse, M., Talsma, D., & Theeuwes, J. (2010). Grabbing attention without knowing: Automatic capture of attention by subliminal spatial cues. *Journal of Vision, 7*(7). http://dx.doi.org/10.1167/7.9.1081. 1081-1081.
Murdock, B. B. (1962). The serial position effect of free recall. *Journal of Experimental Psychology, 64*(5), 482–488. http://dx.doi.org/10.1037/h0045106.
Newell, B. R., & Shanks, D. R. (2014). Unconscious influences on decision making: A critical review. *Behavioral and Brain Sciences*, 1–19. http://dx.doi.org/10.1017/S0140525X12003214.
Nisbett, R. E., & Wilson, T. D. (1977). Telling more than we can know: Verbal reports on mental processes. *Psychological Review, 84*(3), 231–259. http://dx.doi.org/10.1037/0033-295X.84.3.231.
Olson, J. A., Amlani, A. A., & Rensink, R. A. (2012). Perceptual and cognitive characteristics of common playing cards. *Perception, 41*(3), 268–286. http://dx.doi.org/10.1068/p7175.
Polito, V., Barnier, A. J., & Woody, E. Z. (2013). Developing the Sense of Agency Rating Scale (SOARS): An empirical measure of agency disruption in hypnosis. *Consciousness and Cognition, 22*(3), 684–696. http://dx.doi.org/10.1016/j.concog.2013.04.003.
Pronin, E., & Kugler, M. B. (2007). Valuing thoughts, ignoring behavior: The introspection illusion as a source of the bias blind spot. *Journal of Experimental Social Psychology, 43*(4), 565–578. http://dx.doi.org/10.1016/j.jesp.2006.05.011.
R Core Team, (2014). R: A Language and Environment for Statistical Computing. Vienna, Austria: R Foundation for Statistical Computing. Retrieved from <http://www.r-project.org>.
Rozin, P., Scott, S., Dingley, M., Urbanek, J.K., Kaltenbach, M. (2011). Nudge to nobesity I: Minor changes in accessibility decrease food intake 6(4), 323-332.
Shalom, D. E., de Sousa Serro, M. G., Giaconia, M., Martinez, L. M., Rieznik, A., & Sigman, M. (2013). Choosing in freedom or forced to choose? Introspective blindness to psychological forcing in stage-magic. *PLoS ONE, 8*(3), e58254. http://dx.doi.org/10.1371/journal.pone.0058254.
Shiv, B., & Fedorikhin, A. (2011). Heart and mind in conflict: The interplay of affect and cognition in consumer decision making. *Journal of Consumer Research, 26*(3), 278–292. http://dx.doi.org/10.1086/209563.
Simmons, J. P., Nelson, L. D., & Simonsohn, U. (2011). False-positive psychology: Undisclosed flexibility in data collection and analysis allows presenting anything as significant. *Psychological Science, 22*(11), 1359–1366. http://dx.doi.org/10.1177/0956797611417632.
Thaler, R. H., & Sunstein, C. R. (2008). *Nudge: Improving decisions about health, wealth, and happiness*. Yale University Press.
Wansink, B. (2007). *Mindless eating: Why we eat more than we think*. Random House LLC.
Wansink, B., & Sobal, J. (2007). Mindless eating: The 200 daily food decisions we overlook. *Environment and Behavior, 39*(1), 106–123. http://dx.doi.org/10.1177/0013916506295573.
Wegner, D. (2003). *The illusion of conscious will*. MIT press.
Wickham, H. (2009). *ggplot2: Elegant graphics for data analysis*. Springer.