A Psychologically Based Taxonomy of Magicians' Forcing Techniques:

How magicians influence our choices, and how to use this to study psychological mechanisms.

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1. Introduction

"Pick a card, any card. This has to be a completely free choice." the magician tells you. But is it really? Although we like to think that we are using our free will to make our decisions, research in psychology has shown that many of our behaviours are automatic and unconsciously influenced by external stimuli (Ariely, 2008; Bargh & Chartrand, 1999; Newell & Shanks, 2014; Nisbett & Wilson, 1977), and that we are often oblivious to the cognitive mechanisms that underpin our decision (Wegner, 2002, 2003). Magicians have exploited this illusory sense of agency for a long time, and have developed a wide range of techniques to influence and control spectators' choices of such things as card, word, or number (Annemann, 1933; Banachek, 2002a; Jones, 1994; Turner, 2015). These techniques are instances of what is called *forcing*.

Many forces are extremely effective, illustrating various weaknesses in our sense of control over decisions and their outcomes. Researchers have started to investigate them in various ways (Kuhn, Pailhès, & Lan, 2020; Olson, Amlani, Raz, & Rensink, 2015; Pailhès & Kuhn, 2020b, 2020c; Shalom et al., 2013) and are beginning to obtain valuable insights into decision-making processes as well as a better understanding of the cognitive mechanisms that lead people to experience an illusory sense of free will and of agency.

Although magicians have acquired large amounts of knowledge in covertly controlling people's choices, much of this knowledge is only discussed in the context of individual magic tricks, or in books that are not readily accessible to non-magicans. As we and others have argued elsewhere (Ekroll, Sayim, & Wagemans, 2017; Kuhn, 2019; Kuhn, Amlani, & Rensink, 2008; Kuhn, Caffaratti, Teszka, & Rensink, 2014; Macknik et al., 2008; Olson et al., 2015; Olson, Landry, Appourchaux, & Raz, 2016; Shalom et al., 2013; Thomas, Didierjean, Maquestiaux, & Gygax, 2015), a particularly effective way of making this knowledge more

available is via the creation of taxonomies centered around psychological mechanisms (Rensink & Kuhn, 2015). For example, the psychologically based taxonomy of misdirection (Kuhn et al., 2014) helps draw links between misdirection and formal theories of perception and cognition.

Our aim here is to apply a similar process to the knowledge magicians have about forcing. The present paper develops a psychologically based taxonomy of forcing techniques with two goals in mind. Firstly, it should help uncover the various psychological mechanisms that underlie forcing techniques. Secondly, it should facilitate knowledge transfer between magicians and psychologists. Among other things, this knowledge will allow researchers to gain new insights into the mechanisms underlying decision-making, and the feeling of free will and of agency over choice. We start by defining the magician's force and then look at some of the past classifications of forcing.

2. What is forcing?

Although there is no universally accepted definition of a magician's force, it can be thought of as a way of influencing spectators' choice without them becoming aware of this influence (Kuhn, Amlani, & Rensink, 2008; Olson et al., 2015; Shalom et al., 2013; Thomas et al., 2015) (Here, we use "choice" as an umbrella term comprising the spectator's decision as well as the item or thought that results). While frequently a part of card tricks, forces are also used in a much wider range of situations. In some instances, the magician has full control over the process, while in others they simply increase the probability of the person choosing a particular item. It is important to note that forces are distinct from techniques such as sales pitches: in the magician's force, the choice has been affected, but the person is not aware that the magician tried to aim at a particular outcome. Indeed, once the spectator realizes that his/her decision has

been influenced, the magical effect typically evaporates. A lack of awareness of the force is therefore essential.

A successful force has two key components: 1) the technique has to significantly affect the spectators' decision or the outcome of their choice, and 2) the spectator involved has to feel free in their choice, and in control of the outcome they get. Because of this second component, we will not consider techniques where the illusory freedom over a choice is only provided to the audience, but not the person making it (e.g. when the magician explicitly asks the spectator to choose a particular card unbeknownst to the rest of the audience); these techniques are similar to using a confederate, and so do not tell us much about forcing. Likewise, we do not include those techniques which allow the magician to know which card was freely selected—e.g., when the magician uses a marked deck (cf. Cole, 2020). As the main focus of our taxonomy is on spectators' illusory freedom and agency over their choice, such techniques do not fit in these situations.

Forcing is sometimes described as "the act in which a subject reports to have made a free decision among equal possibilities while manipulated by the performer" (Shalom et al, 2013), or "forcing occurs when a magician influences the audience's decision without their awareness" (Olson et al, 2015), suggesting that the force must affect the subject's decision. But as pointed out in a critique of forcing as a method for psychological research (Cole, 2020), many forcing techniques allow the spectator to make a genuinely free decision, but their decision has—unbeknownst to the spectator—no impact on the item they end up with. As Lewis Jones states "there are two types of selection that a spectator can make. In one, the selection is indeed forced. But in the other, the selection is genuinely free" (Jones, 1994, p.8). In some tricks, then, a magician can influence the spectator's decision with subtle verbal and nonverbal cues; in others, the spectator has a free decision but the outcome is unavoidable.

2.1 Free will and agency in forcing

An important part of a force is the spectator's feelings of free will and agency during the trick. Interestingly, in spite of an apparent consensus as to the experience of free will , there is little consensus as how to define it; indeed, the possibility of its existence has been debated for centuries. As psychologists, however, we are simply interested in what makes one act *feel* freer than another; as such, we believe that the most useful view of free will is in terms of degrees (see also Appourchaux, 2014; Baumeister, 2008; Pailhès & Kuhn, 2020a). Here, we take the view that two systems guide our behaviour. One, often called System 1 (Kahneman, 2011), runs the show most of the time and uses automatic processes. The other, called System 2, can intervene to make changes; it relies on more deliberate, conscious behaviour. As Baumeister notes, "free will should be understood not as the starter or motor action but rather as a passenger who occasionally grabs the steering wheel" (2008, p.14). In this case, free will involves self-regulation and conscious decision-making. Indeed, conscious deliberation that acts against our own short-term interest tends to make people feel that their actions are freer (Stillman, Sparks, Baumeister, & Tice as reported in Baumeister, 2008).

In the context of forcing, then, a spectator would make a freer decision when this decision appears to have fewer restrictions and biases imposed by the magician. As we will see later, some forces use diverse psychological biases and restrictions to influence the spectator's decision (see Decision forces section), while others do not (see Outcome forces section). In this latter case, the spectator makes a completely free decision which is deliberate and controlled, but has no impact on the outcome. Interestingly, spectators generally fail to notice that their decision has no impact.

Sense of agency is defined as a person's sense that they are the author of their own actions and their consequences. Explicit measures commonly require participants to state how much control they feel they had over the outcome of their action (e.g. Balslev, Cole, & Miall, 2007;

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Ebert & Wegner, 2010; Metcalfe & Greene, 2007; Sato & Yasuda, 2005). We suggest that this is an important measure to consider in forcing, as it provides an implicit way of assessing whether the spectator understands that their decision had no impact on the outcome.

3. Previous classifications

Forcing is central to magic (Kuhn et al., 2008), and magicians have developed several informal classifications or taxonomies. These predominantly focus on the methods (e.g., prepared decks, "stop" forces, switches of cards) or objects (e.g., cards, numbers, envelopes, ropes) used to realize the tricks.

Among the earliest classifications is that by Theo Annemann, who wrote *202 Methods of Forcing* (Annemann, 1933). Here, forces are classified based on the broad method or object used: Unprepared cards, prepared cards, deck changes, number forces and miscellaneous forces. This classification tends to group techniques which do not provide the same guarantee of result, or for which very different methods are used. Indeed, Annemann states that he "has found it next to impossible to actually classify every method because it would mean cross-indexing practically everything [he has] written". The author also presents techniques which he considers to be forces and that we will not, either because the spectator has no feeling of control over the outcome or because the magician discretely peeps at it. For example, in one technique a card is freely selected, but the magician knows which one it is thanks to a system of marks. Again, we will not consider such techniques as forces, as they do not fit our working definition and likely have little interest for psychologists (see What is forcing? section).

A more systematic approach was developed by Sharpe in "Conjuror's Psychological Secrets" (1988) in which forcing techniques were divided into two main categories: direct and indirect (Figure 1).
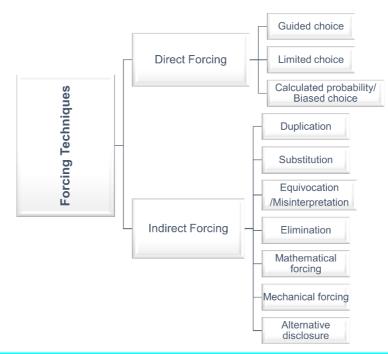
Figure 1. Schematic diagram of Sharpe's classification of forcing techniques. The higher levels are organized according to psychological mechanisms involved, while lower ones are organized according to the methods used.

Direct forcing refers to situations in which the spectator is "allowed to make an apparently free choice; yet the conjurer skillfully causes him to select the one he desires" (p.39). These were subdivided into 3 categories: Guided Choice, Limited Choice and Calculated Probability. It is noted that such forcing relies on a good understanding of "mental reactions"—e.g., people tend to follow a path of least resistance unless they have a reason to do otherwise. Meanwhile, *indirect forcing* refers to all other techniques, in which a genuinely free and uninfluenced choice is made but in which some artifice is used to end up with the conjurer's predetermined outcome. Based on the methods involved, Sharpe divides these into 7 types: Duplication, Substitution, Equivocation/misinterpretation, Elimination, Mathematical Forcing, Mechnical Forcing and Alternative Discosure (Figure 1).

Almost a decade later, Lewis Jones wrote the *Encyclopaedia of Impromptu Card Forces* (Jones, 1994), which describes techniques that the magician can use without any special preparation. Jones classifies forces in various ways, such as "combination forces" (using combinations of objects such as cards and coins, envelopes or calendars) and "multiple forces" (made to force several cards). One of the categories, "probability forces", groups forces that increase the likelihood that the desired card will be chosen. This classification therefore bases its categories on the methods used by the performer (e.g. combination force), the goal of the trick (e.g. multiple force) and even its efficiency (e.g. probability forces). No psychological principles are used.

Banachek wrote three influential books on forcing (*Psychological Subtleties* 1-3, Banachek, 2002, 2006, 2009), including forces that can be used for mimicking psychic powers such as mind-reading or telepathy. These techniques rely on what magicians refer to as *psychological forcing*. Some rely on spectators providing stereotypical answers when asked to think about shapes, animals or numbers. (For instance, if a spectator is asked to choose a number between one and five, the most common answer is three.) Other techniques rely on the cards' visual saliency, or use verbal or non-verbal primes to force a shape or specific card. These books also describe many other techniques. For example, chapter 8 deals with combining techniques to influence spectators' choices (e.g. card positioning, visual riffle, reverse psychology), and techniques aimed at finding the spectator's chosen card thanks to ideomotor effect or changes in pupil size. Once again, the forces are not systematically categorized, and are intermixed with techniques which we do not consider to be forces.

Finally, Peter Turner's book (Turner, 2015) focuses entirely on psychological forces. The author states that "a psychological card force relies on nothing more than subtle verbal guidance, there is no deck of cards, they never take one out, they simply think of it" (p.4). Turner mentions that this type of force does not provide the magician with a 100% success rate

and often needs back-up plans. However, his book does not formally rganise these forces, and combines forces that rely on very different techniques, such as stereotypical choice of cards and semantic ambiguity, as well as tricks we do not consider to be forces—e.g. techniques that rely on ideomotor effects to find the card that the spectator freely chose.
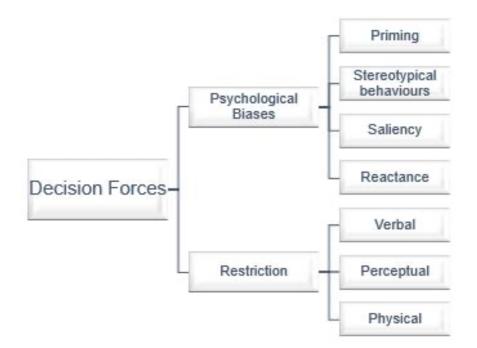
4. A psychologically based taxonomy

The primary purpose of any taxonomy of magic is to organize the methods and effects used in known magic tricks (Kuhn et al., 2014; Rensink & Kuhn, 2015). Most forcing techniques can only be carried out with specific items, such as cards. As such, past taxonomies tended to focus on the nature of the object being forced or the method used. But since we are interested in connecting tricks with the cognitive mechanisms involved, our taxonomy follows the principle of *maximal mechanism*: as much as possible, it should be based on general psychological mechanisms rather than particular methods (Kuhn et al., 2014). Consequently, the basic unit of the taxonomy is the component involving a single perceptual or cognitive mechanism; the force can be in several categories if it is a compound effect drawing upon several processes (e.g., a method that depends on errors both in reasoning and memory). To the best of our knowledge, no such classification of forcing techniques has been attempted yet. Our taxonomy begins by dividing forces into two main categories, based on the two kinds of mechanisms that magicians try to influence: Decision forces and Outcome forces[1].

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[1] As magic literature often does not reference the creators of tricks such as the ones mentioned in this paper, we have found it difficult to crediting magicians for the creation of all the mentioned forces. We tried our best and consulted experts in the field, but cannot guarantee that we gave full appropriate credits for all the techniques.

5. Decision Forces

The first main category is the set of *decision forces*. These are techniques in which the magician directly manipulates the decisions made—for example, the magician increases the likelihood that a particular card will be selected by making it more visually salient or physically accessible. Here, the spectator's decision (e.g. to think of a particular card) is not entirely free, but instead has – if the force is successful – been altered from what it would have been.[2] For most decision forces, there is a considerable risk of failure. This means that they are only employed in situations where the performer can cover the failure through some other technique. But when they do work, they are extremely powerful, because it is virtually impossible to work out how the trick is done.

Fig. 2 **Schematic diagram of decision forces**. Here, the initial level is based on the general kind of cognitive error used (psychological biases or failure to notice restrictions). Later divisions are based on the particular perceptual and cognitive mechanisms.

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[2] This is similar to Direct forcing in Sharpe's taxonomy (Figure 1). However, all divisions in the taxonomy here are based on perceptual and cognitive mechanisms rather than mechanical aspects of the trick.

Our working definition of a decision force includes the magician influencing a spectator's decision without them noticing that their choice has been manipulated. To be effective, then, a force must exploit mechanisms that participants are unaware of. Within this category, we can identify two types of force: *psychological biases*, and *restrictions*.

5.1.   Psychological biases

Many forces exploit people's natural behavioural and cognitive biases, i.e., their inherent tendencies to choose particular items or actions over others.   Magicians can often influence these by manipulating the situational context. Three psychological principles are commonly used: priming, stereotypical behaviour, saliency, and reactance.

5.1.1. Priming

The idea of using unconscious stimuli to influence people's thoughts and behaviours has long attracted public and scientific interest (see Norretranders, 1999). Not surprisingly, then, this idea has also been applied to magic, in the form of *priming forces*. These are techniques where the magician alters the tendency of the spectator to name a target object. Conjurers typically use both verbal and nonverbal primes. For example, in the Mechanical breakdown force (by Christian David, in Banachek, 2006) the spectator is asked to imagine a specific situation (e.g., a shopping afternoon during which your car breaks down) using a script filled with words such as "negative", "positive" and "electrified". David claims that when the spectator is asked to name the outcome of the story (i.e. what do you look at under the hood of your car), most people will answer "battery". Here, the keywords are believed to prime the spectator's mind with the predetermined outcome.

It is unclear how well that particular force works in practice, but we have investigated a related force and found relatively high success rates (Pailhès & Kuhn, 2020a). Derren Brown's force (Brown, 2002) relies on techniques that use subtle hand gestures to prime people to name the three of Diamonds. These gestures, combined with verbal cues, significantly increase the chances of people doing so: 18% of participants chose the three of Diamonds (the most commonly chosen card), and nearly 40% chose a three of any suit, with most participants oblivious to the prime's influence. Further investigation showed that both verbal and nonverbal primes can have a significant impact on card choices (Pailhès & Kuhn, in preparation). Although this kind of force has relatively low success rates, the subtlety by which it influences participants' choice is very powerful. We believe this type of technique opens the door to many interesting opportunities to investigate phenomena such as priming with gestures, the influencing of thoughts and decisions, and the failure to notice that choice is being manipulated.

5.1.2. Stereotypical behaviours

Back in 1894, Alfred Binet investigated magicians' techniques scientifically, observing that conjurers often exploit spectators' "laziness" without the spectators becoming aware of it (Binet, 1894). Forcing techniques often use this natural laziness, making one option easier than the others. In particular, they often exploit stereotypical behaviour (French, 1992; Marks & Kammann, 1980), using the fact that when presented with a specific situation or question, most people choose and answer the same thing.

We can divide such behaviours into mental selections and behavioural actions. For example, if asked to name a number between 1 and 10, people are most likely to name 7 (Banachek, 2002a; French, 1992). French has shown that 37% of subjects chose the number 7 when asked to choose a number between 1 and 10 that is not 3. In unpublished work, we showed that even without excluding the number 3, 7 is still the most common choice (25% of choices,

with 3 being chosen 7% of the time). Banachek's "pretty flower" force relies on a similar principle (Banachek, 2002a); he notes that, when asked to name a pretty flower, most spectators will name a rose. Unpublished pilot data from our lab confirms this. Magicians also exploit the fact that some cards are more commonly named than others (e.g. Ace of Spades). Olson and colleagues (Olson, Amlani, & Rensink, 2012) found systematic differences in the probability of people naming various playing cards; an informal online study using more than 350 000 choices provided very similar results, with the most commonly chosen cards being the Ace of Spades, Queen of Hearts, Ace of Hearts, Ace of Diamonds and King of Hearts (Scam Nation, n.d.). One potential issue with investigating this type of force is that spectators may be aware of these biases. Indeed, unpublished pilot work from our lab shows that when explicitly asked about the proportion of people who would name the same object as them, people are surprisingly good at judging it.
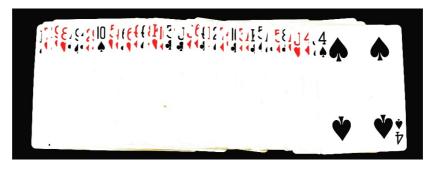
Meanwhile, much of our behaviour is highly predictable, and such stereotypical actions are commonly exploited. For example, in the Position force the magician places four cards in a row on a table and asks the spectator to touch one; since people tend to select items that are more reachable, right-handed people will choose the third card from their left more frequently (Banachek, 2002a; Hugard, 1974; Pailhès & Kuhn, 2020b). We investigated this technique (Kuhn et al., 2020; Pailhès & Kuhn, 2020b) and showed that around 60% of participants choose the forced card. Interestingly, participants again seemed oblivious to this bias, significantly underestimating the number of people they thought would also select this card, and reporting feeling free and in control of their decision.

5.1.3. Saliency

A popular way of biasing a person's decision is to increase the saliency of target items (i.e., the extent to which they visually stand out from their surround), making these more likely to be

chosen. This echoes various theories of visual attention in which attention is guided by saliency (Itti, 2001; Koch & Ullman, 1984; Ouerhani, Von Wartburg, Hugli, & Muri, 2003; Treue, 2003). Magicians have developed a wide range of forces that rely on this principle, which is essentially a form of attentional misdirection (Kuhn et al., 2014).

The use of saliency in playing cards has been widely documented (Banachek, 2002a; Hugard, 1974; Jones, 1994). For example, Olson et al. (2015) used the Visual riffle force in which the magician flips through a deck of cards and asks the spectator to visually select one of them. Unbeknownst to the spectator, the target card was shown slightly longer than the others and so became more salient. Under some conditions a large majority (98% of participants) chose the target card while being unaware that their choice had been influenced, and feeling completely free in their choice. A related example is the spreading of a deck of cards on a table, with one of the cards' surfaces being more exposed than all the others (Banachek, 2003, see Figure 3).

Figure 3. Example of a spread of cards using saliency forcing. Here, exposing the 10 of Spades more than the other cards causes it to be selected more often than it otherwise would.

5..1.4. Reactance

Some forces use what amounts to reverse psychology. In these, the spectator tries to maintain their freedom of choice by choosing the least obvious / most odd card—and in doing so, ends up in the trap. *Reactance* is the psychological process which occurs when one's freedom is perceived asthreatened, and one then acts to re-establish this freedom (J. W. Brehm,

1966; S. S. Brehm & Brehm, 1981; Steindl, Jonas, Sittenthaler, Traut-Mattausch, & Greenberg, 2015; Torrance & Brehm, 1968). In these forces the magician uses what has been named *strategic self-anticonformity* (MacDonald, Nail, & Harper, 2011). As MacDonald et al. note, "in these situations, an influence source may have success by misrepresenting their true desires assuming that the target's proclivity for disagreement will result in the target adopting the position that the source secretly desires" (p.2). Although the risk in using this strategy is that the person will agree with what is asked, magicians usually push for reactance, saying for example, "This has to be a free choice, do not let me influence you, alright ?".

A famous example of this is Dai Vernon's five-cards force (Banachek, 2002a; Hugard, 1974). This technique consists in putting on a table five carefully chosen cards, typically the King of Hearts, seven of Clubs, Ace of Diamonds, four of Hearts and nine of Diamonds, presented from left to right. These cards are chosen to make some of them less appealing than the others, both because of their value (e.g. four of Hearts compared to an Ace) and their position (4th position from the left of the spectator rather than the far-left position not often chosen). The magic literature reports that because of this, the four of Hearts is the most commonly chosen card, followed by the nine of Diamonds (Banachek, 2002a). In an empirical investigation of this (Pailhès & Kuhn, in preparation), we found that the four of Hearts was indeed the most chosen card (32% of choices), followed by the nine of Diamonds (26%). But this happened only when reverse psychology instructions were used; if we presented these same cards to participants while simply asking them to make a choice, the Ace of Diamonds was chosen most often (33%). Thus, both the positions of the cards and task instructions affect participants' choices. Moreover, in Vernon's original script, when presenting these cards, the magician emphasizes that the Ace is a famous card and is in the middle, and that the seven is the only black card, which is supposed to increase the spectator's suspicion about them (Hugard, 1974). Banachek states that "by mentioning [this], that leaves them with the King of Hearts,

which is very suspicious because it is a picture card" and that the four of Hearts is more likely to be chosen as "it is not at the end of the spread and is in fourth position" (Banachek, 2002a). However, contrary to this prediction, our data show that Vernon's original script made participants significantly less likely to choose the four of Hearts (13% of choices) compared to simple reverse psychology instructions (41% of choices, Pailhès & Kuhn, in preparation).

5.2 Restriction

A common way for magicians to force a particular decision is by restricting the number of options that the spectator will consider. These *restrictions* can be verbal, perceptual, or physical. Interestingly, in most cases the spectator fails to notice the restriction.

5.2.1. Verbal restriction

Several forces restrict the number of choices by including subtle constraints within the general verbal instructions given to the spectator. This narrowing down of possibilities can be done either by directly eliminating them or by naming them as examples. For instance, if the magician asks you to think of a simple geometric shape but announces "But not the square— it's too obvious", this enhances the probability that you will choose a triangle (Banachek, 2002b). Simply naming or including items in the instructions is also known to be effective. For example, asking a spectator to choose a number "between one and ten" implicitly restricts their choice to eight numbers.

Two famous examples of verbal restriction are the 68 and 37 forces (Fulves, 1975; Gardner, 1956). Here, the conjurer asks the specator to think of a two digit number; the magician then specifies that the two digits are both odd, are different form one another, and the complete number is between 10 and 50. In this case, most people think of the number 37. Likewise, when asked the same thing and restricting the result to an even number between 50 and 100, the

spectator will usually think of 68. Scientific studies have verified that for these instructions, the two target numbers are indeed chosen significantly more often (Trinkaus, 1980).

5.2.2. Perceptual restrictions

Sometimes, the spectator's choice is restricted by allowing them to see only a limited number of items properly. For instance, the visual riffle force can be performed in such a way that the predetermined card is not only more salient but also the only visible card of the deck. Likewise, the fan/spread types of forces can use the same principle.
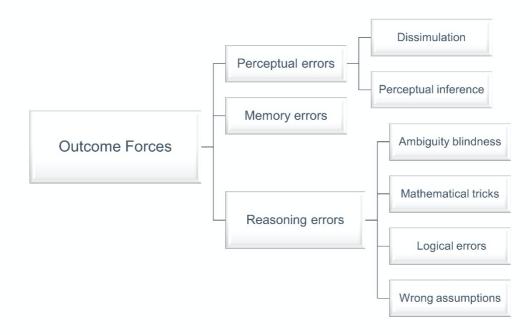
5.2.3. Physical restriction

Many forces use physical constraints to make it more likely that the target card will be chosen. For example, the Classic force, one of the most popular forcing techniques, requires the magician to handle the cards in such a way that the forced card is the one under the spectator's fingers when he reaches out to touch one of them. Shalom et al (Shalom et al., 2013) investigated this force and showed that 54% of participants picked the forced card while feeling completely free of their choice.

6. Outcome Forces

Magicians use a wide range of psychological principles to influence a spectator's decision, with some of these principles being more successful than others. However, most forces rely on manipulating the impact of the spectator's decision, rather than the actual decision made (Cole, 2020). For these *outcome forces*, the spectator has—and makes—a genuinely free decision, but unknown to them, this decision has no impact on the outcome of the trick. A key principle here is that the spectator does not understand that their choice cannot affect the outcome of the procedure. For example, imagine you are asked to select a playing

card from a deck where all cards are identical; even though you are free to choose any card, each selection will have the same outcome. These forces guarantee that the spectator will end up with the forced item because the choice is either ignored, or the chosen item is covertly switched for another one. That is, the freedom to decide is not impaired, but the spectator has no control, no impact, over the outcome of this decision. Three main kinds of error can be exploited in these forces: perceptual, memory and reasoning errors (figure 4).

Fig. 4. Schematic diagram of outcome forces. The initial level is based on the general type of cognitive error used (perceptual, memory and reasoning errors). Later divisions are based on the particular perceptual or cognitive mechanisms involved.

6.1. Perceptual errors

A large number of forces rely on surreptitiously switching the chosen item for the force item. Such forces are based on the spectator's erroneous perception of the true event sequence. Typically, some part of the sequence is hidden from the spectator, or performed in a way that deliberately results in a perceptual error. For example, the spectator can freely touch a card

among other cards spread out in a fan; the selected card is then covertly switched for the target card. Two principles can be used to influence the spectator's perception: dissimulation, and errors in perceptual inference.

6.1.1. Dissimulation

Here, the spectator simply does not see the true event sequence. For example, the spectator is asked to choose a card from a deck; their choice is covertly switched using sleight of hand, or by doing the trick under the table, or some similar method. An interesting application of this is choice blindness. Here, participants are asked to select one of two items shown; a concealed switch then forces participants to end up with the item they rejected in the first place (Hall & Johansson, 2005; Hall, Johansson, Tärning, Sikström, & Deutgen, 2010; Hall et al., 2013; Stille, Norin, & Sikström, 2017). Interestingly, people usually fail to notice they ended up with the item they initially rejected; when asked to justify their choice, people confabulate reasons as to why they chose the initially rejected item. A large number of forces fall within this category; magicians may use sleight of hand, gimmicked props or other mechanical devices to conceal the switch.

6.1.2. Errors in perceptual inference

Perceptual inference refers to the ability to make sense of the visual information given. Forcing techniques can rely on the complexity and speed of the movements performed to make it difficult for the spectator to correctly infer the true event sequence.

Consider, for example, the Hindu shuffle (Figure 5). This consists in shuffling a deck by holding the cards in the right hand, taking some cards from the top of the deck with the left thumb and middle fingers, and then dropping them in the left hand; done repeatedly, this results in a shuffled deck of cards in the performer's left hand. The the spectator can say "stop" whenever they want the magician to stop shuffling. The magician then stops and shows the bottom card of the deck in their right hand.

Figure 5. Illustration of the Hindu shuffle force. From the beginning the seven of Diamonds is at the bottom of the deck. The magician drops the top cards of the deck (A) in their left hand, and repeat the process (taking the B top cards and droping them as well). When the spectator says "stop", the magician simply turns their right wrist and shows the bottom card of the deck.
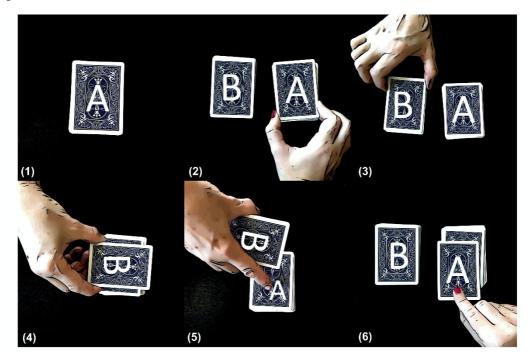
Because the actions are hard to follow, spectators end up thinking that the outcome card was determined by the moment they said "stop". If the spectator truly were in control, however, the card shown would be the top—not bottom—of the left- or right-hand pile. But the shuffle, done quickly and with a right-hand gesture going up and down each time some cards are taken with the left hand, confuses the spectator, who then wrongly perceives the forced card as a shuffled one.

The same type of mechanism seem to be involved in the Flushtration Count trick (Thomas, Didierjean, Kuhn 2018), involving an illusion of having seen multiple cards with identical backs, when in fact only the back of one card is repeatedly shown.

6.2. Memory errors

Outcome forces can also cause the spectator to form an incorrect memory of an event sequence. A good example is the Criss-Cross force (Pailhès & Kuhn, 2020c, Figure 6). This consists of asking a spectator to cut a deck of cards and place the top pile next to the bottom one. The magician then takes the bottom pile and places it on the top one in a crossed figure. After this, the spectator is asked a question in order to direct their attention away from the deck and create a time delay. The magician then raises the top pile and asks the spectator to take the top card of the bottom pile (the top card of the original deck), casually stating "Go ahead, take your card". Magicians commonly believe that this moment is what makes this force successful, as it confuses the spectator about which card is where (Pailhès & Kuhn, 2020c). However, after investigating this force, we concluded that this misdirection is not the critical factor. Instead, the key mechanism appears to be attribute substitution (Kahneman & Frederick, 2012), a heuristic in which people replace a complex and unfamiliar event with a simpler and more typical one. Applied to the Criss-Cross, this means that spectators substitute the unfamiliar cutting procedure with a more typical one, "remembering" that they cut to a card and got this one.

The Criss-Cross also constitutes a good example of a force using multiple mechanisms. Most participants misremembered the event sequence, and so failed to understand that they had no control over the outcome. But our results suggest that the unusual shape of the cross is also important: participants noticed that they were forced significantly more often when the cross shape was removed from the procedure. Both memory and perceptual inference therefore seem to be involved. Interestingly, our experiments also demonstrated that magicians sometimes attribute a trick's success to the wrong factors. As such, more controlled types of experiments can not only bring new insights to psychological research, but also a better understanding of tricks for performers.

Figure 6. Criss Cross Force main steps: From the beginning the forced card is on the top of the deck (A). In (2) the spectator cuts the deck of cards, in (3/4) the magician puts the bottom pile on the top of the top one in a cross shape, (5) the magicians removes the top pile and tells the spectator to take "his/her card" by pointing at the forced card, and in (6) the spectators ends up with the forced card which he/she believes to be the other card, selected by the cut.

6.3. Reasoning errors

Outcome forces often rely on erroneous reasoning about the event sequence that led up to a selection—for example, the spectator can fail to understand that the calculation the magician asked them to make with their chosen number will always lead to the same final number. Four kinds of reasoning errors can be identified: 1) ambiguity blindness, 2) limitations in mathematical thinking, 3) logical errors, and 4) wrong assumptions.

6.3.1. Ambiguity blindness

These forces use what we called *ambiguity blindness*—the failure to recognize ambiguous siutations—to create an illusion of choice. For these, the spectator fails to notice that their choice could be interpreted in different ways. A famous example of this is the Équivoque, or Magician's Choice. Here, the magician deals two cards on a table and asks the spectator to touch one. Suppose the conjurer wants the person to end up with the card on the spectator's right. If they touch this card, the magician <u>keeps</u> it and discards the other. But if the spectator touches the card on their left, the magician <u>discards</u> this choice and keeps the one on the right, resulting in the same outcome. This procedure can be applied to items other than cards, and is often used with a larger number of items.

The Équivoque is one of the most powerful forces in magic (Banachek, 2002a). We have investigated this technique empirically, and found it to be highly effective in providing an illusory sense of control over the outcome of an action (Pailhès & Kuhn, n.d.-b). Interestingly, participants were often oblivious to the semantic inconsistencies in the procedure used to guide their decisions.

Many forces rely on ambiguity blindness. For example, place two pairs of cards face down on a table and ask the spectator to choose one. One pile consists of a three and a four, and the other pile two sevens. Adding the values in the former pile results in a number seven, whilst

the other pile constitutes of only sevens. While the spectator is free to choose either one, this will result in the same outcome – the number seven. After the selection, the magician can then show a written prediction that he had, stating "You will choose the seven pile". In this force the spectator lacks information that the outcome of their choice could have different meanings and another choice would have led to another interpretation of the outcome.

6..3.2. Limitations in mathematical thinking

A wide range of forces rely on clever mathematical tricks: by following a predetermined procedure, or using a specific device (e.g. trick dice), a fixed outcome is guaranteed, regardless of the starting point. These forces work because the spectator does not have the appropriate knowledge to see that their choice will not change the outcome. These techniques differ from ambiguity blindness forces in that the outcome of the spectator's action is never altered; the spectator simply fails to notice that the procedure necessarily results in the same outcome. For example, if you throw a die and add the two opposite numbers, you will always end up with a seven. Choosing a random number, (i.e. 27), multiplying it by 2 (54), adding 10 (64), dividing it by 2 (32) and then subtracting the chosen number chosen from this number (27) always ends up with the number 5 (Annemann, 1933).

Likewise, the Kruskal Principle (Nishiyama, 2013) uses probabilities to force a playing card. Here, the spectator shuffles a deck of cards and the cards are displayed on the table in rows of ten. Then the spectator is asked to pick any card of the first row and use the value of that card to count along the deck (picture card being worth 5). When the spectator lands on a new card they then use the value of that card as their new number and repeats the process until they run out of card (SingingBanana, 2010). Despite the seemingly random path, the conjurer can predict the spectator's last card: there is a 84% chance that the spectator ends up on the same card regardless of the first chosen card.

6..3.3. Logical errors

In contrast to tricks based on limitations of mathematical thinking, tricks based on logical errors use materials that require no calculation. An example is the Top Cards dealing force (Jones, 1994): the spectator is asked to take a deck of cards, and start dealing them by taking one card at a time from the top of the deck. The spectator chooses when they want to stop dealing. When the spectator stops, the magician asks them to do the same thing with the pile created, this time making two piles (dealing one card on the left side, the next one on the right side and so on). The magician then announces that the chosen card will be a combination of the two top cards of the piles: the value of one and the suit of the other.

Here, combining the different events (dealing cards, making a pile, making two different piles from it, combining the two top cards) and letting the spectator handle the cards for the entire duration of the trick provides an illusory sense of control over the outcome. The different actions and divisions of cards into different piles make it hard for a spectator to understand that what they just did had no influence over the result. Indeed, the top two outcome cards are in fact the two cards which the magician placed at the top of the deck before giving it to the spectator. The spectator's choice – when to stop dealing – as well as the fact that they were the only one touching the cards, had no impact on the outcome of the trick. This is intuitively hard to understand as a relatively large number of cards is usually dealt by the spectator at the beginning. This type of trick illustrates Wegner's exclusivity principle (Wegner, 2002, 2003)— i.e., our feeling of control over events comes in part from the fact that we do not see any other possible cause for what happened.

6.3.4. Wrong assumptions

We all bring assumptions about the world to a magic performance. And in many instances, these assumptions are wrong. A large number of forcing techniques therefore exploit erroneous

beliefs about the magician's actions, objects, or concepts. For example, you may assume that the magician uses a deck with 52 different cards when in reality all 52 are identical. If you freely choose one of the cards in such a deck, your assumption will cause you to incorrectly believe that your choice had an impact on the final outcome.

7. Conclusions

Magicians have developed an enormous number of forcing techniques. These rely on a wide range of psychological principles, but all aim at the spectator ending up with a predetermined outcome while having an illusory sense of free will and of control over their actions. These illusions touch on several important issues—e.g., understanding how we make our decisions, what makes one action feel 'freer' than another, and what makes us believe that we are in control of our actions. As we have shown here, studying the processes involved can provide valuable insights into decision-making, new ways to encourage better decisions in regards to health and well-being, and a better understanding of what leads people to experience a sense of agency. Moreover, we also believe it is important to raise awareness about how easily choices can be manipulated, to protect people against unwanted influences (e.g. marketing, or political propaganda).

To facilitate the transfer of knowledge between magicians and researchers, our classification has organised knowledge based on the psychological mechanisms involved. The main division into decision and outcome forces can be used as a way of focussing separately on (1) decision-making processes, and (2) the sense of agency over actions and outcomes (including the illusion of control over these outcomes). The subcategories of this taxonomy can allow us to get a more detailed idea of which psychological principle is used for a particular force to be successful. (To illustrate this, a classification of Anneman's 202 forcing techniques (Annemann, 1933) is shown in the Appendix, based on our taxonomy). Note that a particular

technique can fit into several of our categories if it combines different principles (e.g. restriction and saliency for the Visual riffle force, reasoning and memory for the Criss-Cross).

Alternative taxonomies are of course possible, and we encourage future research to develop them. We believe these may also be useful for research, and help to cast further light on issues related to the feeling of free will and agency, and various aspects of decision making.
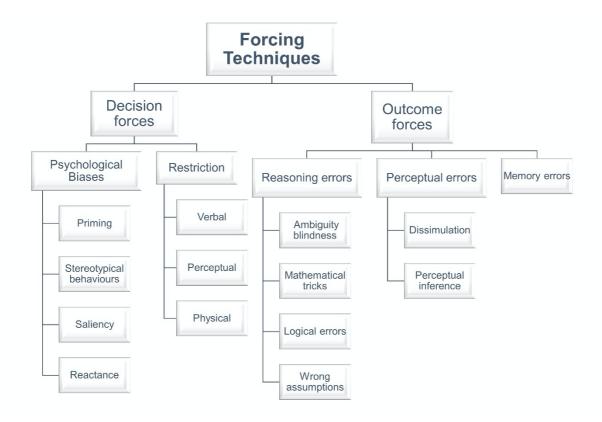

Fig. 7 Schematic diagram of all the forcing techniques.

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