Forcing techniques & Neuroscience

David Bestue¹

¹Institut d'Investigacions Biomèdiques August Pi i Sunyer (IDIBAPS), Barcelona, Spain

Although we might think our decisions determine the final outcome of certain situations, magicians show us this is not always the case. Over the centuries, magicians have developed numerous *forcing techniques* to determine the final outcome of certain decisions that are perceived as “free choices” by the spectators. It has been hypothesized that forcing techniques could be of extreme value to explore both decision making process and free will. Unfortunately, the knowledge of forcing techniques is restricted to magicians, who usually study them from a practical perspective instead of a psychological one. As this hinders the transfer of knowledge between the fields, in this work, I present an accurate explanation of the general concept of “forcing technique” together with a discussion of their possible applications to neuroscience. Moreover, I present a framework of cognitive processes exploited by forcing techniques to illustrate they are complex mechanisms that different branches of neuroscience can study. This work provides a background for the application of this ecological tool in the neuroscience of decision making and the sense of free will.

Introduction

-“You can do what you will, but you can’t will what you will” -

Arthur Schopenhauer, 1839

As human beings, we are constantly making decisions. However, the contribution of conscious and unconscious processes in decision making is still unclear. The “conscious automata” view ([Huxley, 1874](#)) proposes that consciousness is irrelevant for decision making. This view proposes consciousness is only responsible for producing the awareness of intentions. This view has recently become more popular with experiments that showed that future decisions can be decoded from brain signal before they reach consciousness ([Libet, 1985](#); [Soon et al., 2008](#); [Haynes, 2011](#); [Soon et al., 2013](#); [Koenig-Robert & Pearson, 2019](#)), suggesting that free will is an illusion. There is controversy regarding the validity of this statement ([Klemm, 2010](#)), as it largely depends on how “free will” is defined as well as in differentiating between conscious and unconscious processes ([Morsella, 2005](#); [Koch & Tsuchiya, 2007](#)). This open debate made some scientists to look for different methodological approaches.

Magicians are able to make their spectators believe they are making a free decision while controlling the final output. The procedures magicians use for that goal are called “forcing techniques”. These techniques seem very appealing to study free will, as they allow the experimenter to control the final outcome of an apparent “free decision”. By fixing the outcome of a decision, the parameters that lead to this decision as well as its neural correlate can be explored. However, nearly no research has

been done with forcing techniques (Olson et al., 2012; Shalom et al., 2013; Olson et al., 2015; Pailhès & Kuhn, 2020a; Pailhès & Kuhn, 2020b; Pailhès et al., 2020b), mainly because they remain exclusive for magicians. Recently, Cole, (2020) proposed that researchers have exaggerated what magicians achieve with forcing techniques, and, nearly a month later, Pailhès et al., (2020a) published a taxonomy of forcing techniques to promote the research in the psychology of influence. To what extent forcing techniques are valuable for neuroscience requires both a detailed explanation of what a forcing technique is and a framework where forcing techniques are described from the neuroscientific perspective.

Aiming for a framework that translates forcing techniques into neuroscience, Pailhès et al., (2020a) proposed a psychology-based taxonomy of forcing techniques where they are initially classified depending on whether the spectators make an influenced choice -decision forces- or whether they make a genuine free choice -outcome forces-. The decision forces are later classified depending on whether the amount of possible choices are reduced (restriction) or whether psychological biases are used. Regarding the outcome forces, they are later classified depending on if they rely on reasoning, perceptual or memory errors. However, this taxonomy has some gaps that should be solved to be an effective framework for neuroscientists. First, it mixes psychological processes (e.g. psychological biases) with magician's methods (e.g. restriction), which is inconvenient to destil the reasons why a certain forcing technique works. Second, some categories are inaccurate from the neuroscientific perspective. "Perceptual errors", for instance, includes forcing techniques that rely on pre-sensorial methods -maneuvers the spectators are physically not able to see- so they are not "incorrectly" perceived, just not perceived. And third, it does not capture that forcing techniques are complex mechanisms that exploit multiple cognitive processes simultaneously, so classifying the processes these techniques exploit is probably much more useful for neuroscientists. For these reasons, an alternative framework to understand and apply forcing techniques into neuroscience is needed.

Here, I will start by making a detailed explanation of what a forcing technique is. Then, I will propose an alternative framework to understand how forcing techniques work purely based on cognitive processes. To illustrate the complexity of forcing techniques, I will dissect one of them and show that the cognitive processes exploited, and not the techniques *per se*, are what should rule the framework. Finally, I will discuss the possible applications of forcing techniques into the neuroscience of free will and decision making as well as the advantages of this new framework to translate magician's knowledge into neuroscience.

Results

Forcing techniques: Definition & Process

Although definitions are always tricky, I will start by giving mine before giving a detailed explanation of the general structure of these techniques. For me, forcing techniques are: ***“Techniques that allow the magician to predict the final outcome of the spectator’s decision without them being aware of it”***. In my definition, I try to get away from the terms “influence” (Kuhn et al. 2020; Olson et al., 2015; Pailhès et al., 2020b) or “manipulate” (Shalom et al., 2013) as they do not represent what happens in the majority of these techniques (Cole, 2020). Besides, the terms “magician” and “spectator” are incorporated in the definition, as forcing techniques occur in the context of a magic trick, which is not irrelevant at all to ensure this efficacy. Finally, this definition does not imply a fixed prediction accuracy and, as it focuses on the outcome instead of the processes that accomplish it, it remains open to include different cognitive processes.

Understanding what a forcing technique is, however, goes beyond defining it. In Figure 1, I present a schematic view of what a forcing technique is. A forcing technique consists of a pre-decision period, a decision period and a post-decision period before the decision is revealed. In the pre-decision period, the magician already knows the set of possible outcomes of the decision. In most of the forcing techniques, the length of this set of outcomes is one, as the magician usually needs a specific outcome to match with a “prediction” he will reveal later on. In other more flexible cases, however, the magician may have more than one outcome. In any case, the magician knows, in advance, what is going to be the outcome of the decision process. This is key to differentiate forcing techniques from other techniques where the information of a certain decision is discovered by the magician after the process. The second period starts when the magician presents the decision to the spectator. In this period, the spectator is presented a set of choices. It is important to note that the set of choices the spectator perceives may not be the real set of choices he has. In some forcing techniques, the set of choices perceived by the spectator is the same as the real set of choices but, in others, the real set of choices is smaller than the perceived one (with some options repeated or more exposed without the spectator noticing it, for example). After the spectator makes the decision, we enter in the post-decision period, which contains the time that goes from this decision until the final revelation. Sometimes, this period is nonexistent, as the decision is in itself a revelation (e.g. the spectator “says” a number). In other situations, however, there is a gap between the decision and the revelation. During this period, the perceived set of choices of the spectator must remain the same. If the spectators perceives his set of choices have been manipulated, the forcing technique is not effective. Moreover, the spectator must feel his selection is invariant, this means the magician does not surreptitiously change it. During this final process, the magician evaluates the decision and may do something that ensures this decision matches with the set of outcomes.

Figure 1. Schematic view of a forcing technique. Three different periods are presented: the pre-decision period, where the magician has a set of desired outcomes, the decision period, which goes from the decision presentation until the moment the spectator decides. In this period the spectator perceives a set of choices that can match, or not, the real set of choices the magician presents. And, finally, the post-decision period, where the perceived set of choices remains unaltered and the spectator believes his decision can not be changed. In this final period, the magician evaluates the decision and decides how to proceed accordingly.

For clarification, in Figure 2 I make the case of three real forcing techniques that aim the same outcome: “force the number 7” but by affecting each one of the three periods. In Figure 2A, the magician relies on previous information regarding which is the most likely option the spectator is going to choose. In the case of choosing a number from 1 to 10, 7 is the most likely decision (Banachek, 2002). In this specific forcing technique, the magician does not actively manipulate the real set of choices'. However, some options are more likely than others without the spectator being aware of it. In Figure 2B, I expose an example of forcing technique where the magician actively manipulates the real set of choices without the spectator being aware of it. In this forcing technique, the magician uses a gestual-priming procedure to increase the probability of the spectator choosing that number 7. Up to this point, I am presenting examples where the forcing techniques are not 100% reliable, so, depending on the decision the spectator makes, the magician may have different solutions to consider during the “decision evaluation”. An example of forcing technique that is 100% secure that acts during the decision period would be showing 10 cards with numbers going from 1 to 10 and, without the spectator noticing, changing them for 10 cards with the number 7 in all of them. In that scenario, the perceived set of choices would be 1/10, but the real set of choices would be 1. In Figure 2C, I expose an example of forcing technique where the magician changes the outcome of a choice. In this case, the magician presents cards going from 1-10, mixes them and asks the spectator to pick one of them face down. After the decision is done, by using sleight of hand, the magician changes the chosen card for the card of the 7. Up to the moment of the decision, the perceived set of choice was equal to the real set of choices (1/10). However, the spectator was wrong assuming his choice was invariant. To emphasize the decision evaluation process, in this particular example the magician evaluates if the spectator picked the card with the 7. If he actually did it (1/10 of the times), the magician does not need to do anything. If he didn't, the magician must change the card secretly.

A

B

C

Figure 2. Examples of forcing techniques affecting different periods. All the forcing techniques presented here are about the spectator picking the number 7 without knowing the magician predicted that in advance and without feeling any kind of manipulation. Each subfigure represents the period of the decision process the magician is operating.

(A) Pre-decision period. In this forcing technique of the number 7, the magician knows the stereotypical response of the spectators when a number from 1-7 is required, so the subsequent periods are not affected. **(B)** In this forcing technique of the number 7, the magician manipulates the real set of choices without the spectator being aware of it by using a gestual-priming procedure that increases the probability of the spectator choosing the number 7. **(C)** In this forcing technique of the number 7, the spectator freely chooses a card from a set of cards that goes from 1-10 but the identity is not immediately revealed. The magician, in the post-decision period, uses sleight of hand to secretly change the chosen card for the card with the 7.

After explaining what a forcing technique is highlighting these three periods (pre-decision, decision and post-decision), one might be tempted to classify them depending on which one of these periods is affected (Pailhès et al., (2020a) partially followed that with the Decision forces / Outcome forces distinction). However, if we want an effective transfer of knowledge between magic and neuroscience, I do not recommend this classification for two reasons. First, because different cognitive processes can be exploited within the same period, and second, because forcing techniques may rely on manipulating more than one period at the same time. The example presented in Figure 2B, for instance, would never be independent of the example presented in Figure 2A. Magicians try to maximize the effectiveness of their forcing techniques, so they will operate in more than one period if necessary. Therefore, if we aim for an effective transfer of knowledge, we should first explain in detail the cognitive processes exploited by forcing techniques and, later, locate them properly in the different decision periods.

Forcing techniques: Framework

Pre-sensory forcing techniques

Some forcing techniques rely, to some extent, on a previous set up of the deck of cards or on sleight of hand. Both methods, when performed correctly, are sensory inaccessible to the spectators. An example of it would be when the spectator selects a card from a spread of cards and, by using sleight of hand, the card is changed under the deck (Tamariz, 1980; Simon, 1983). Pailhès et al., (2020a) included these forcing techniques in the category of “perceptual errors”. Perception requires the interpretation of sensory information so, if information does not even reach the brain, we can not talk about errors in perception. Although forcing techniques does not exclusively rely on pre-sensory mechanisms, it is important to keep in mind that part of the success of these techniques is explained by events that do not affect any cognitive process. Forcing techniques relying on sleight of hand are the most difficult ones because if the spectator detects the sleight, the forcing technique will instantly fail, as the spectator will likely interpret an alteration in his perceived set of choices or a violation of the invariability of his selection (the sense of freedom of the decision would be lost). The pre-sensory component of forcing techniques could be used to study perceptual thresholds (Hergovich et al., 2011) or to study how the detection of one solution prevents the spectator to find new ones (Thomas et al., 2018).

Cognitive processes exploited by forcing techniques

Forcing techniques exploit different cognitive processes that are relevant for the final decision. In this classification, I differentiate the following cognitive processes: Decision making, Reasoning, Memory, Perception and Attention (Figure 3) and I put examples of forcing techniques that exploit each mechanism. It is important to note that cognitive processes are not independent, as they share neural resources. Furthermore, forcing techniques are complex procedures and their success usually depends on more than one process. To illustrate this point clearer, I will extensively describe the different processes a specific forcing technique exploits in the final section of the results.

Figure 3. Cognitive processes exploited by forcing techniques.

1. Decision making

Although decision making could arguably be the final cognitive process exploited by forcing techniques, other processes are also affected. In this section, however, I will just enumerate those processes that are typically associated exclusively with decision making.

1.1 Energy saving

Making decisions implies an energetic cost. To save energy, we tend to minimize effort in our decisions ([Christie & Schrater, 2015](#); [Balle, 2002](#); [Kool et al., 2010](#)), following the famous [Hull's \(1943\)](#) law of less work: *"If two or more behavioral sequences, each involving a different amount of energy consumption or work, have been equally well reinforced an equal number of times, the organism will gradually learn to choose the less laborious behavior sequence leading to the attainment of the reinforcing state of affairs. (p. 294)"*. Magicians constantly exploit that principle by presenting the desired choice as the one that requires less energy consumption. An example of that would be, in the situation the magician needs the spectator to pick a red card, to arrange the deck in a way all the red cards are on top and all the black cards are on bottom. If the magician then makes a spread on the table in a way the top section is closer to the spectator, it is very likely the card will be removed from there, as picking a card from the top section requires less muscle movement than picking a card from the bottom section (it would require the spectator to even stand up). Similarly, if the magician places four cards in front of a right-handed spectator (Position force - [Hugard, 1974](#)), he will pick the third card from their left around 60% of the time ([Kuhn et al., 2020](#)), as it is the one more "reachable". This concept does not apply just to physical movement, also to cognitive effort. Magicians usually rely on stereotypical behaviours, knowing that some outcomes are more likely than others due to our cultural context. For instance, if the magicians makes you think of a country

that starts with the letter “G” it is much more likely that you will think in “Greece” before “Gabón”, and the same occurs with numbers, flowers, geometric shapes (Banachek, 2002), playing cards (Olson et al., 2012), etc. For this strategy to be effective, the spectator must appreciate that wasting energy in the decision process is useless. I will address how this can be achieved in the following point.

1.2 Expectation

Preventing the spectator to anticipate what is going to happen is a golden rule in magic. In the context of forcing techniques, magicians try to minimize the inspection the spectators put in the decision process. Magicians use their attitude and their body language to communicate the card the spectator will pick is not relevant, promoting the energy saving strategies presented just before to increase the probabilities to pick the forced card. The spectators not knowing what is going to occur with the selected card is a common strategy exploited by magicians because, in case the forcing technique does not work, they can proceed with a different trick without anyone noticing. To successfully manipulate spectators’ expectations, the magician is always concerned to find justifications for his moves. Certain situations that may look casual are actually motivated by the magician to use certain moves that, otherwise, would look suspicious. Let’s suppose, for example, that the spectator who has to pick a card is sat in the third row of the theater. It is then expected the magician extends his arms more than usual to approximate the deck to the spectator. By doing so, the magician will be able to reduce the amount of cards displayed to the spectator, increasing the effectiveness of the forcing technique. If the spectator would have sat in the first row, that action would have generated a lot of contrast (Camí et al., 2020), as it would have been unnecessary. Another way to manipulate expectation is by giving extra instructions besides “taking a card”. An example of that would be: “I want you to pick a card and then I want you to choose between your right and your left pocket and put the card there”. The extra instruction of selecting a pocket might be completely irrelevant for the trick, but it makes the spectator expect the relevant part of the decision is something different than the card, so much less inspection would be put in the selection, making the forcing techniques more effective.

1.2.1 Reactance

In some rare cases of forcing techniques, the magician makes the spectators put extra inspection into the procedure of selecting a card and uses “reverse psychology” to force the desired card. In these situations, the magician presents obvious outcomes, so the spectators try to avoid them and go for the less obvious one. However, this less obvious outcome is the one desired by the magician. The psychological phenomena presented here is called reactance (Brehm, 1966), and occurs when we perceive our freedom has been limited and we act to re-establish it. The best example of it is Dai Vernon’s five-cards force (Hugard, 1974), where 5 cards are placed face up in front of the spectator and he is asked to pick one. The value, color and position of the cards together with the speech the magician gives, makes some cards more “obvious” than others, so the spectators systematically avoid them and end up picking the forced card.

1.3 Compliance

Compliance is the submissive response made in reaction to a request (Cialdini & Goldstein, 2004). The authority figure that the magician represents together with the stress related to standing up in front of an audience makes the spectators more likely to follow the magician's instructions. Some forcing techniques work better in stage situations than in close up. The "stage environment" (elevated position, distance, spotlights, sound, etc.) puts extra stress on the spectators, who usually feel unpleasant under these situations. This makes the spectator less likely to inspect the different options of a certain decision and makes him more likely to follow energy saving strategies (1.1). In-group/out-group effects are an important part of compliance (Sowden et al., 2018), so having a challenging attitude towards the magician in front of a crowded audience is not a good strategy to "fit in" (unless the magician is being disrespectful with the crowd). Another example of how compliance can be used in the context of forcing techniques is the tendency to pick women instead of men. Women are, on average, more compliant than men (Grosch & Holger, 2016). When magicians use a forcing technique that is not 100% reliable, they tend to pick women to increase the rate of success.

1.4 Reaction time

Certain forcing techniques rely on the magician's control of the spectator's reaction time. By performing the same technique hundreds of times in front of different people, the magician knows when the spectator is more likely to respond, so the magician uses this to match the spectator's response with the card to be forced. In Dani Daortiz's "stop force" (DaOrtiz; 2011), the magician controls the card to be forced to the bottom section of the deck and starts to deal groups of cards from the top of the deck until the spectator says "stop". Experience with the dealing speed and the size of the groups of cards dealt, makes the magician able to synchronize the response of the spectator with the dealing of the remaining cards on top of the card to be forced.

1.4.1 Urgency

By reducing the variability of reaction times, the magician can predict when the spectator will respond more accurately. A commonly used strategy to accomplish that consists in generating urgency. Making decisions under time pressure makes people less likely to engage in cognitive tasks (Beach & Mitchell, 1978; Edland & Svenson, 1993; Ordóñez & Benson, 1997). Therefore, magicians usually add time constraints in their forcing techniques, so spectators can not think for a long time what is the decision to make. This strategy, combined with the previously described 1.3 *Compliance* allows a high rate of success in forcing techniques that are not 100% secure. An example of it is the "classic force" (Reginald, 1584). In this forcing technique, the spectator is asked to pick one card from a spread the magician holds in his hands. The efficacy of the force relies on matching the finger of the spectator with the card to be forced in the spread. To accomplish that, among other things, the card is usually placed at the last third of the deck and the spectator is asked to pick a card after half of the deck has already been spread. The spectator then realizes he has to hurry to pick one before he runs out of cards, so he reaches into the deck quickly, with no meditation. By doing so, the magician has been able to control the moment the spectator will reach into the deck with much more accuracy (few seconds of variability), so it is much more easy to match the finger of the spectator with the card to be forced.

2. Reasoning

Some forcing techniques rely on our limited reasoning capacity to solve certain problems. In this section, I will differentiate those that rely on mathematical, general-spatial and verbal reasoning and put some examples of each.

2.1 Mathematical

Magicians carefully select their repertoire depending on the audience they are acting to and also pick the methods that will more effectively fool each audience. In that sense, no magician will pick tricks that rely on “exposed” mathematical operations in front of an audience of mathematicians, who would easily follow what is happening. This does not mean, of course, that you can not do magic tricks that rely on mathematical principles in front of that audience, but you should be careful that the method is hidden. Inside the mathematical reasoning, I will differentiate the forcing techniques that rely on arithmetic calculations and the ones that rely on the numberline.

2.1.1 Arithmetic

Our limited capacity to make several mental calculations avoid us from discovering some forcing techniques that rely on simple mathematical calculations. Some forcing techniques rely on formulas that, regardless of you making a genuine free decision, you end up in the same number. For instance, if I ask you to pick a number from 10 to 20 and then subtract to it the sum of the digits, it does not matter which number you picked at the beginning, you will end up at number 9 (e. g. 15: $15 - (1+5) = 9$; 18: $18 - (1+8) = 9$). Although this process is very simple, more complex formulas are developed where the mathematical explanation is much more hidden. It is important to note that, although many forcing techniques rely on mathematical processes, they are also combined with other methods that help them to preserve the sense of freedom.

2.1.2 Number line

When asking a number from 1 to 10, 25% of the people go for number 7 ([Banachek, 2002](#)). It is not clear why this occurs, and further research should be done to determine if this is a cultural effect of the popularity of number 7 in our culture or it is due to something else. Here, I will speculate that we have a tendency to go for middle to high numbers of the range given. Magicians asking for numbers from 1 to 20 usually get numbers higher than 15 ([DaOrtiz, 2009](#)) and a similar thing occurs when varying the range (1-30, 1-52 etc.). I speculate that, in front of a big range, picking a small number feels like a “waste” of opportunities, so most people will pick higher numbers. I could not find relevant scientific literature addressing this phenomena, so this section is pure speculation arising from the magic literature.

2.2 General and Spatial reasoning

Some forcing techniques exploit the incomprehension of the topographical nature of the elements used. Magicians are very familiar with the properties of a deck of cards, but this is not the case for most of the audience. An example of it would be the hindu force ([Annemann, 1939](#)). In this technique, the magician holds the cards in the right and takes some cards from the top of the deck with the left hand. This is done continuously, so while the cards on the left hand are being mixed,

the ones in the right hand remain in the same order. When the spectator says stop, the magician shows the bottom hand of the right hand, which has been the same during the whole procedure (bottom card). An accurate topographical knowledge of both the deck of cards and the movements would make this forcing technique ineffective, but spectators are not able to do that in the context of a magic trick. Another example of it is the Criss-Cross force (Holden, 1925). In this forcing technique of the top card of the deck, the spectator cuts the top half on the table and then places the bottom half on top in a crossed manner (Figure 4). Then, the spectator is asked to get the card “they cut to”. To do so, the magician takes the new top half and indicates the top card of the bottom section. The card the spectator takes is the card that was originally placed on top of the deck and not the real card he cut to. Pailhès & Kuhn, (2020a) extensively inspected why this forcing technique works. They concluded it is a memory error in the form of an attribute substitution (Kahneman & Frederick, 2012) where spectators apparently change the memory of the unfamiliar event with a typical and more standard one. An alternative hypothesis consistent with their result is that the expected outcome of the “take the card you cut to” statement implies taking a card out from the center of the deck in the topographical conception the spectator has about the deck of cards. The Criss-Cross force perfectly accomplishes it, so no contrast is generated as the card in the middle of the deck looks less controlled than the one on top of the deck from the spectator’s perspective. A follow up experiment to demonstrate that would be to reproduce the Criss-Cross cut sequence and, without pointing to any specific card, ask the spectator to “pick the card they cut to”. I hypothesize that they will still pick the card in the middle of the deck, because spectators do not fully comprehend the topography of a deck of cards and cutting to a card implies taking it from the middle of the deck, not from the extremes.

Figure 4: Criss-Cross force. The card to be forced (e.g. Ace of spades) is located on the top of the deck (1). The spectator cuts the deck (2) and the bottom section of the deck is placed on top diagonally marking the separation (3). The card removed from the middle of the deck is the one to be forced, initially placed on the top (4).

2.3 Verbal reasoning

Magicians carefully select their words when performing. Picking the right words and phrasing them in a casual manner is a great strategy to achieve certain goals. Our limited verbal reasoning capacity makes us never question why the magician used a certain word and not a synonym of it. In a context of selecting a card, using words like “take” or “pick” instead of “chose” or “select” is a clear example of that, as the first ones imply much less inspection in the decision process than the second ones. Regarding more complex reasoning that still remains elusive to the spectators, the use of ambiguous sentences is also extensively used in magic. In the forcing technique “magician’s choice” (Decremps, 1985), the magician uses a sentence like “point to one of these objects” and, depending on the answer of the spectator, the magician proceeds to pick the object or to discard it. The lack of a context regarding the process is taking place (the spectator does not know in advance if you are

keeping or discarding) combined with our blindness to detect ambiguous sentences, makes the “magician’s choice” undetectable, even when inconsistencies are presented in subsequent decisions (Pailhès et al., 2020b).

3. Memory

Magicians manipulate our memories to make their tricks more impressive and memorable (Tamariz, 2019). Similarly, they also exploit memory processes to make forcing techniques more effective.

3.1 Associations

An association is a connection between concepts or events that usually stems from specific experiences (Klein, 2012). Magicians both exploit already present associations and generate new ones in their forcing techniques.

3.1.1 Actual

We assume specific features to the objects that surround us. A deck of cards for instance, is composed of individual rectangles of paperboard that have different values printed on them. Magicians can exploit the stereotypic features associated with objects to disguise their secrets. For instance, we wrongly assume, whenever we see a deck of cards that all of them are different. A forcing technique that uses a deck that consists of 52 repetitions of the same card works because of our limited knowledge of the different types of decks of cards. A magician with experience, for instance, will hardly be fooled by this methodology, as he/she will question some features of a deck of cards that a lay person does not.

3.1.2 Creation

Forcing techniques occur in the context of a magic performance not as individual events. Therefore, magicians can create associations between a certain methodology and a free outcome so we trust a similar methodology in the future, which outcome is not free. Arturo de Ascanio coined the term “conditioned naturalness” (Etcheverry, 2000), which means that every movement should look exactly the same whenever it is tricky or legit, so it does not generate any contrast. In forcing techniques, this principle is applied when first using a certain mechanic when the spectator picks a genuine free card (association gesture-free outcome) and later using the same mechanic to force a card. Dan Harlan, for instance, uses this principle with two genuine selections followed by a “classic force” in his version (Harlan, 2007) of the *Circus card trick* (Braue & Hugard, 1948).

3.2 Retrieval

Our memories define who we are and what we like (Weber & Johnson, 2006). Memory retrieval is the process of recalling stored information, and it is exploited by magicians by knowing what is the most likely information we are going to retrieve. When a magician asks for a “preference” it is possible he already knows this information. Preferences are quite stable across time, so maybe the magician obtained that information time ago without us noticing. Let’s suppose, for example, the magician knows our favourite number is 12. He could then secretly place the card to be forced in the 12th position and ask us to make a “free decision” according to our preferences and deal cards one by one until the position of our favourite number. Nowadays, the use of social media has made this

kind of forcing techniques much more accessible, as we are not aware about the amount of information we share. Besides using personal preferences, magicians rely on “cultural preferences” or “stereotypical responses”. As a part of a society, we receive similar inputs and education. This fact, combined with the previously mentioned “Energy saving” (1.1), makes some answers more expected than others. Examples of that would be the “pretty flower” forcing technique by Banachek ([Banachek, 2002](#)), where most people use to pick the flower “rose” or “Between the lines” of Michael Murray ([Murray, 2014](#)), where the magician guesses correctly a whole story the spectator “makes up” using just stereotypic responses. Regarding playing cards, Olson and colleagues ([Olson et al., 2012](#); [Olson et al., 2015](#)) found that some playing cards were named more frequently than others, like the Ace of spades or the Queen of hearts.

3.3 Iconic memory

Stimulus presentation leaves a trace in the sensory system after it disappears ([Dick, 1974](#)). This type of memory is called iconic memory ([Sugita et al., 2018](#)), and some rare forcing techniques take advantage of the filling in mechanisms supported by this type of memory ([Camí et al., 2020](#)). In different versions of the Kinetoscopic Force ([Masqué, 1897](#); [DaOrtiz, 2014](#)) the magician asks the spectator the glimpse a picture card and then riffles in front of a spectator a deck of cards that contains the values cards of a certain suit (e.g. spades) and a picture card of the matching color suit (e.g. King of clubs). Due to retinal persistence ([Coltheart, 1980](#)), the previous spades cards make the spectator not to notice the picture card was of a different suit, so the card the spectator says does not even need to be inside the deck (e.g. King of spades).

3.3.1 Priming

The phenomena by which environmental stimuli may affect subsequent responses without conscious realization is known as priming ([Graf et al., 1984](#); [Weingarten et al., 2016](#); [Mulckhuyse et al., 2007](#)). This process is seen as a form of implicit memory ([Schacter, 1987](#); [Begg et al., 1992](#)), as it works by activating a certain memory representation before the task is introduced ([Heath et al., 2012](#), [Trübutschek et al., 2017](#)). Some rare forcing techniques exploit this by subconsciously influencing the spectator before the choice. In a recent paper, [Pailhès & Kuhn \(2020b\)](#) analyzed a forcing technique which relies on subtle hand gestures to prime spectators to name the three of diamonds ([Brown, 2002](#)). They observed that 18% of participants chose the desired card (1.9%, chance level) and up to 40% chose any three (7.7%, chance level).

3.4 False memories

How we remember magic tricks is arguably more important than how we experience them in the present moment. The words we use to describe an event can change the memory of that event in future recalls ([Loftus & Pickrell, 1995](#); [Loftus, 2003](#); [Drivdahl et al., 2009](#)). Magicians exploit that to increase the power of the effect every time it is recalled ([Tamariz, 2019](#)). Forcing techniques also exploit the use of false memories to create, during the course of the performance, the idea that the selection procedure was more free than it actually was. If we take the criss-cross forcing technique, where the forced card is on top of the deck, exploiting false memories would be, for example, to convince the spectator he shuffled the deck before the cut. Sometimes, false memories have to be

actively created by the magicians. These desinformation procedures gradually include fake information at different stages of the trick, usually disguised with real information (DaOrtiz, 2009).

Besides trying to change the memory of a forcing technique with desinformation techniques *a posteriori*, magicians also rely on how we passively remember a sequence of events. Episodic memory consists of picking the relevant pieces of information so the event can be reconstructed later on (Wheeler et al., 2000; Monk et al., 2021). Therefore, how a certain event is presented can lead to remember it as more free than it actually was. An example of that would be David Williamson's variation of the "slip force" (Williamson, 2014). This technique forces a card by using sleight of hand in the context of a cut. However, in Williamson's variation, the card is finally extracted from a spread, so the event the spectators will remember is them taking a card from a spread instead of selecting it from a cut. The temporal domain can also be manipulated to maximize the feeling of freedom. In the force of the card at the seventh position, the magician starts to slowly deal cards on the table. When 5 cards have already been dealt, the magician conveniently places the instruction: "you have to stop me at one card" (Hugard & Braue, 1974; DaOrtiz, 2009). Besides exploiting "1.4.1 Urgency", this forcing technique also works because the spectator will remember he could have said stop at any moment, forgetting he did not know what to do until five cards had already been dealt.

3.5 Capacity and Decay

Some forcing techniques rely on the limited capacity of our working memory as well as on the limited amount of time we can maintain them (Engle, 2001; Klingberg, 2009). Not all forcing techniques rely on a single discrete time point where a certain action takes place. In others, the spectator goes through several steps before getting the final outcome (e.g. 2.1.1 Arithmetic). Our working memory limitations make us forget some of the steps, so we can not reconstruct the whole process later on and discover how the forcing technique worked. An example of that would be a forcing technique where the spectator is presented with several images in a matrix and is instructed to put his finger in any of them. Then, he will move from picture to picture freely but with certain rules (number of movements, avoiding diagonal movements...). At the end of the process he always ends up in the same picture although he could have followed different paths (Gardner, 1987).

4. Perception

In this section, I will enumerate the forcing techniques that exploit how we interpret available sensory information.

4.1 Recognition

In order to recognize a certain stimulus, it has to be exposed for a certain time (Thorpe, 1996). Its shortest exposure at which recognition occurs is called "recognition threshold". In some forcing techniques, the magicians exploit this by exposing some elements under the recognition threshold and just the one to be forced above it. The most popular forcing technique exploiting this is the rifle force (Tarbell, 1927). In this forcing technique, the deck of cards is quickly rifled in front of the spectators and asked them to remember one. In the process, the only card the spectator is able to recognise is the card to be forced, as it is displayed for a bit longer than the rest. The difficult part of

this forcing technique is to disguise this increased exposure, so the different exposing times are not obvious. This forcing technique is typically used for magic performed in TV, cinema (first scene of the film “Now you see me”) or computer, as the programmer can manipulate the presentation times in a refined way. In real life situations, the use of gimmicks or extensive practice can minimize the differences of presentation times, making the forcing technique still effective.

4.2 Exposure

Exposing people to a familiar stimulus led them to rate it more positively than others (Zajonc, 1968; Zajonc, 2001). A popular modeling explanation for this effect relates to “perceptual fluency”, which refers to the ease with which information is processed: while familiar information is easily processed, no familiar information is hardly processed. Enhanced evaluations in exposure effects are then explained by the positive effect generated by the dynamics of fluent processing (Winkielman et al., 2003). Some studies found that these exposure effects were more pronounced when obtained with subliminal stimuli, so subjects are not aware of the repeated exposures (Bornstein & D’Agostino, 1992). An example of forcing technique using this principle is by adding 10-15 repeated cards in a deck of cards and then riffle them in front of the spectator before asking them to name the first card that pops into their minds. Someone could debate that this forcing technique could be seen as a kind of repetition priming. The boundaries between repetition priming and exposure effects are not clear (Butler et al., 2004; Butler & Berry, 2004). Literature proposes that exposure effects are related to perceptual fluency (Fang et al., 2007) while priming to implicit memory (Roediger, 1990; Schacter et al., 1993). Specific research regarding how exposure is used in forcing techniques should be done in order to properly address the cognitive processes exploited, but it works to illustrate how forcing techniques can exploit shared mechanisms of perception and memory.

4.3 Saliency

Every item, depending on the context it is presented, has a certain saliency to the extent that it perceptually stands out from the neighbours (Borji et al., 2013). The neural mechanisms that define what is going to capture attention (saliency map) occur at early stages of the visual process, even with stimuli the participants can not perceive (Zhang et al., 2012). In this section, I will explain how magicians increase the saliency of certain items so they are more likely to be selected. The classical example of that would be the face up and face down versions of the spread force (Decremps, 1786; Hugard & Braue, 1974; Banachek, 2002; Tamariz, 2005) in which a spread of cards is presented in front of the spectator and there is a gap that makes one card more visible than the rest. As his example also relies on energy saving strategies (1.1), I will explain a forcing technique that has never been published that exploits saliency in a much clearer way. Tino Call, an excellent magician from Barcelona, subtly marks the back of the forced card. By doing so, the spectators are more likely to pick them in a perfect spread with no gaps, without realising there is a mark on it. As it has not been validated by other magicians, we should be careful about its effectiveness. However, it is a clear example that exploits the selection of the most salient item without consciously noticing.

4.4 Simultaneity

There is extensive literature regarding how visual and auditory information are integrated (Colonius & Diederich, 2010; Kuling et al., 2013; Linares & Holcombe, 2014; Arstila et al., 2020). Desynchronization studies have been used to inspect when the relation is lost. Examples of that are

the spatial desynchronization imposed in the “Ventriloquist effect” (Radeau & Bertelson, 1977; Bruns, 2019) to study the resistance of the illusion or the temporal asynchrony in the “McGurk effect” (van Wassenhove et al., 2007). Studies of visual-auditory integration present the concept of a certain *time window* where they are perceived as related. This concept is used in some forcing techniques, where the magician tries to match a verbal instruction of the spectator with a visual event occurring. The best example of this is the “dribble force” (Giobbi, 1996). In this forcing technique, the magician dribbles the cards (drop them from the right to the left hand, holding them by the short edges) in front of the spectator and asks him to say “stop” whenever he wants. Without the spectator noticing, the magician stops dribbling the cards at the specific point where the forced card is, matching the action with the word “stop” of the spectator. To accomplish that, the magician is secretly holding a separation on top of the desired card and is watching at the mouth of the spectator. As soon as he detects a movement of the mouth (even before hearing the word), the magician drops all the cards below the separation. As spanish magician, I speculate this forcing technique is more popular in Spain mainly because we use the word “alto” instead of the word “stop”. “stop” is monosyllabic and starts with an “s”, so detecting the word is harder than detecting the word “alto”, that has two syllables and starts with an “a” (more mouth movement).

5. Attention

In this final section, I will enumerate how forcing techniques exploit attention. A core concept in magic literature is “*misdirection*” (Ascanio, 1964; Sharpe 1988; Kuhn et al., 2014). In a previous work, I defined misdirection as “those actions of a magic trick that influence the attention of the spectator to conceal the method used” (Bestue, 2019). As forcing techniques are, by definition, “methods”, they will use misdirection whenever they exploit some sort of attentional manipulation with concealing intention. In Bestue, (2000) I presented the first computational model of misdirection using the well known bump attractor model (Compte et al., 2000). To be consistent with my previous work, I will use the same subcategories, adding examples of applications to forcing techniques.

5.1 Direction

The direction form of misdirection refers to moving attention from one initial focus to another and many forcing techniques exploit that principle. In my misdirection classification (Bestue, 2019), I made a further distinction according to how the focus of attention is changed between or within external and internal tracking. In the context of forcing techniques, direction is usually applied to move attention away from the deck (external-external) to make a certain sleight of hand undetected. A common example of it would be looking at the spectator’s eyes when performing sleight of hand. By doing this, the sleight becomes undetectable because the focus of attention is moved away from the deck, as spectators follow the magician's gaze (Kuhn et al., 2009).

5.2 Division

The division form of misdirection refers to generating a competition between two relevant focuses. In the context of a forcing technique, if the magician sets one of the relevant focuses of attention into the deck of cards, adding a simultaneous focus could be accomplished, for example, by asking an irrelevant question to the spectator while performing the forcing technique. With this competing relevant information presented by the magician, the spectators can not focus completely on the decision procedure, as he also has to answer the question made. This makes the spectator rely on

energy saving strategies (1.1 Energy saving) and put less inspection in the procedure of selecting a card.

5.3 Diminishment

The diminishment form of misdirection refers to reducing the detection threshold when performing the technique. An example of it would be the use of gags before doing the forcing technique. Gags create a moment of relaxation that magicians typically use to perform secret maneuvers. In the “dribble force”, for instance, the magician “plays” with the spectator by dribbling the cards very fast so the spectator has no time to say “stop”. This usually gets a laugh and spectators are less suspicious in the following forcing technique. In this specific example, we could also include the “3.1.2 Creation of Associations” as it relies on the same principle of reducing the attentional threshold in the subsequent movements. I keep them separate because the threshold reduction can also be accomplished by using different strategies like the already mentioned gags or other presentation strategies (emotional scripts, music...) that contribute to create an “atmosphere” (Etcheverry, 2000) where the spectators are willing to suspend their disbelief.

Forcing techniques: dissection of the “classic force”

In this final section of the results, I will examine all the cognitive processes exploited by a single forcing technique to illustrate that forcing techniques are complex mechanisms that rely on multiple cognitive processes to achieve the sense of freedom when making decisions. For that reason, it is inaccurate to classify forcing techniques *per se*. Instead, enumerating the cognitive processes they exploit is a much more accurate approach that prevents us from a simplified view of forcing techniques.

The “classic force” is a forcing technique that consists in making the spectator take the desired card from a spread of cards the magician holds between his hands. The efficacy of the technique relies on matching the moment the spectator places his finger on top of a card with the card to be forced. There are multiple sources and variables of this forcing technique, so I will explain a version that comes from mixing many sources (Reginald, 1584; Ganson, 1959; Hugard & Braue, 1974; Giobbi, 1996; DaOrtiz, 2009).

First, the magician starts by doing a secret maneuver that allows him to maintain control of a card around 15 cards away from the bottom of the deck (**Pre-sensory**). Then, the magician waits some time before starting to spread the cards (Ganson, 1959), exploiting memory decay (**3.5 Capacity and Decay**) to temporally separate the action that allowed you to control the card at that position from the “picking action”. That way, the spectators can not create a causal link between them (Ortiz, 2006).

Once the spreading action has started, many things must be taken into account: First, the attitude of the magician should communicate the procedure is about to take place (“picking a card”) is not “a big deal”, so it is not deeply analyzed by the spectators (**1.2 Expectation**). Second, the spectator is aware he has to pick the card once half of the deck has already been spread between the hand of the magician (Giobbi, 1996). This fact is crucial to generate urgency in the spectator’s action (**1.4.1 Urgency**) and helps to synchronize the picking action with the desired portion of the deck (where the

card is secretly controlled). Third, the magician uses the expression “*take a card*” instead of “*choose/pick a card*” (**2.3 Verbal reasoning**) in order to sub-communicate the spectator should not “dig into” the deck to make a selection. Finally, by the time the spectator reaches the deck, the card maintained in the separation is much more salient than the other cards of the deck, as a bigger portion of its back is displayed just under the finger of the spectator (**4.3 Saliency**). Everything exposed before together with the implicit tendency to minimize effort in our decisions (**1.1 Energy saving**) will make the forcing technique very reliable.

Furthermore, extra subtle strategies might be used to maximize the effectiveness of the forcing: Dani DaOrtiz (DaOrtiz, 2009) proposes a priming strategy (**3.3.1 Priming**) where the magician starts spreading large groups of cards and then gradually smaller groups of cards as he becomes closer to the card to be forced. By doing so, the magician subconsciously tells the spectator when is the right moment to pick a card. Another strategy is asking a question just before the spectator picks a card (**5.2 Division**). That way, two competing focuses will exist (selecting a card and answering a question) reducing the inspection the spectator puts into the selection process, making the forced card more likely to be picked. Although I have already talked about playing with expectations before, it is surprising that the “classic force” works better when the cards are displayed “face up”. The reason for that is that the spectator expects even less the magician can manipulate his selections when he actually sees the cards, so the posterior feeling of freedom is stronger. Some magicians use a sort of “resistance saliency”, by holding all the cards very strongly except the card to be forced. That way, if the spectators reaches any previous card in the spread, it is going to be really hard to extract from the deck, and it will be quickly passed until the forced one reaches the hand of the spectator. Another strategy is to perform this technique in parlour situations or with female spectators. In the **1.3 Compliance** section I have already discussed why these situations make the effectiveness of this forcing technique increase. A final strategy would be to conditionate the spectators to legitimate versions of this maneuver, so spectators will create an association between the way the card is selected and a free outcome. (**3.1.2 Creation**). When the forcing technique is later used, it will incite much less inspection. Similarly, the creation of a relaxed atmosphere (**5.3 Diminishment**) where the spectators do not perceive the magician as a challenger and where they are willing to enjoy the experience of magic will contribute enormously to make this forcing technique work.

As this is not a “magic publication”, I intentionally avoid a detailed description of the mechanics of the forcing technique. Besides willing to protect the secrets of the magic community, the mechanical details are not interesting for the purpose of the description: illustrating the complexity of forcing techniques to justify why I am reluctant to forcing techniques classifications. Instead, I rather focus on the processes these forcing techniques exploit, which are usually multiple and simultaneous, as in the case of the “classic force”. The reader will also notice that, along the manuscript and also in this example, most of the forcing techniques mentioned use the deck of cards. The reasons for that are the following: first, I wanted to show that forcing techniques are not “element-dependent”, so many cognitive processes can be exploit with the same object and, second, card magic is the branch of magic with more literature, so the majority of forcing techniques are created and tested for playing cards.

Discussion

Over the centuries, magicians have developed multiple ways to force certain choices (Tamariz, 1980). As a mainly practical discipline, magicians have been much more focused on developing new techniques rather than on coining a universally accepted definition or dissecting the essence of these techniques. However, when approaching forcing techniques from the scientific perspective, a detailed understanding of these techniques is required to set a reasonable research potential.

As forcing techniques allow magicians to know the result of a certain decision, it is reasonable to think they could be used to explore the neuroscience of free will. A deterministic view of the world states that the actual physical characteristics of the world make the future state of the world inevitable (Laplace, 1814; Suppes, 1993; Harris, 2012). In terms of predictability, more information regarding the actual state of the world makes predictions more accurate and less information makes predictions worse. The fact that future decisions can be accurately predicted based on brain activity (Soon et al., 2008; Koenig-Robert & Pearson, 2019), challenges the concept of “free will” as an argument against determinism. The simplified rationale is the following: “by knowing the state of the brain before the decision process, we can predict the final decision. Then, free will is an illusion”. One issue regarding this philosophical discussion regards defining “free will” (Klemm, 2010; Morsella, 2005). Is “free will” just circumscribed to the sense of agency? Does it refer to just conscious processes? Another issue is the anthropocentrism (or sentiocentrism) of the term freedom: while we would never attribute the adjective “free” to certain processes like the weather, that can be predicted based on physical variables of the environment, we do apply it to decision making processes that also rely on biophysical variables occurring in the brain. To what extent some procedures, aka forcing techniques, can be useful to address “free will” will largely depend on the definition of the term. I think forcing techniques clearly show that having more information (the magician has more information than the spectator) increases the prediction power of certain situations, but we should be careful when suggesting they can be used to study “free will” without a detailed explanation of the concept.

Those scenarios that have been proposed as useful to study “free will” are the ones where some elements of the real set of choices (Figure 1) are weighted positively without the spectator noticing (Figure 2B). This has also been referred to as the “psychology of influence” (Pailhès et al., 2020a). It is very important to note that forcing techniques exploiting this are very rare as well as very unreliable (lower rates of success compared to other techniques). For that reason, I coincide with Cole (2020) when he states that forcing researchers have probably exaggerated when framing the forcing techniques in terms of “influence” or “manipulate” decisions. I coincide that some forcing techniques can be used to investigate how we can be primed (Brown, 2002; Pailhès & Kuhn, 2020) but I doubt it to be the field where forcing techniques can be more useful. A commonality that all forcing techniques share is that, by the end of the procedure, the spectator believes their perceived set of options has not been manipulated, so forcing techniques could be a unique tool to study how the “sense of freedom” emerges, which is an open topic barely studied in real ecological situations (Metcalfe & Greene, 2007; Bandura, 2001; Wegner, 2003). In Figure 3, I provided a framework with

all the cognitive processes exploited by forcing techniques. By parametrically modulating these processes in different situations, we could weigh the role of memory, perception, attention, etc. in the emergence of the sense of freedom when making decisions. Similarly, forcing techniques could also be used to study the relation between available options and the sense of freedom/agency (Barlas & Obhi, 2013), as magicians can easily increase the perceived set of choices with minor implications in the efficacy of most of the forcing techniques.

A main goal of this work was to translate forcing techniques into neuroscience by enumerating and explaining all the cognitive processes that forcing techniques can exploit. The new framework presented here differentiates cognitive processes associated with decision making, reasoning, memory, perception and attention, so experts from each discipline can take advantage of this new formulation and apply forcing techniques to their own research. The only work I am aware of that tried to classify forcing techniques from a scientific perspective is the one of Pailhès et al., (2020a). They proposed a psychologically based taxonomy of magicians' forcing techniques where forcing techniques were classified according to the psychological principle they used. Although they mention that some forcing techniques could be classified in more than one category, I think this approach could bias the reader to simplify forcing techniques and incorrectly assume that magicians just exploit a couple of psychological principles when using a certain forcing technique. In the final section of the results, I dissected a forcing technique -"the classic force"- to illustrate the richness behind these procedures, where many cognitive processes coexist. Thus, classifying a forcing technique *per se* is very inaccurate from the neuroscientific perspective. Instead, enumerating the cognitive processes exploited by these techniques prevents classification errors.

This framework presents important differences with the one proposed by Pailhès et al., (2020a). Pailhès et al., (2020a) mixes pure psychological categories (like psychological biases or memory errors) with categories that are magician's methodologies or temporal stages. Examples of that would be the categories they call "restriction" or "outcome forces". The first one -restriction-, refers to reducing the amount of options available. This is a clear magician's methodology that has no psychological rule supporting it. The second one -outcome forces- refers to those forcing techniques where the spectator actually makes a free choice. As explained in Figure 1, this is a temporal separation that has nothing to do with the psychological process the magician exploited. Using this classification rule also has the inconveniences that the magician could manipulate more than one period at the same time and that the same cognitive process could be exploited in forcing techniques not classified as "outcome forces". To avoid these problems, I proposed that all the categories and subcategories are well-known psychological processes, with the exception of Attention, whose subcategories refer to the only mechanistic explanation of misdirection that has been published (Bestue, 2020). Finally, I also think that some forcing techniques are not correctly explained in Pailhès et al., (2020a), so I propose alternative mechanisms to them. As examples, Pailhès et al., (2020) classify the riffle force and the criss-cross force as "saliency" and "memory error" respectively. I think the riffle force relies mainly on recognition (the card to be forced is the only card the spectator can actually recognize) and the criss-cross force relies mainly on a topographical misconception of the deck of cards instead of an attribute substitution.

A main limitation of the framework presented here is that it isolates the forcing techniques from the context of the magic trick and the magician. So far, I have presented forcing techniques as complex

maneuvers. However, the complexity increases as more contextual variables are incorporated. The effectiveness of forcing techniques also depends on the magician who performs it as well as in the context where it is presented. The style of some magicians will make some forcing techniques more effective than others in terms of the sense of freedom the spectator feels. Similarly, the context of the whole performance will critically affect forcing techniques. That is why, I encourage forcing techniques -as well as magic tricks- to be studied in the context of a real performance by a professional magician ([Bestue et al., 2020](#)) instead of in the context of the laboratory setting performed by amateur magicians.

To sum up, providing a detailed explanation of what a forcing technique is together with a framework that, instead of classifying forcing techniques, focuses on the cognitive processes they exploit, will contribute to facilitate the transfer of knowledge between magicians and neuroscientists. As magic is an evolving discipline, I presume this framework to grow in order to incorporate future forcing techniques that exploit cognitive processes not listed here. I hope this work will inspire scientists of different disciplines to use magic tricks as a tool to understand the role of different cognitive processes behind both decision making and the feeling of freedom coupled to it.

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