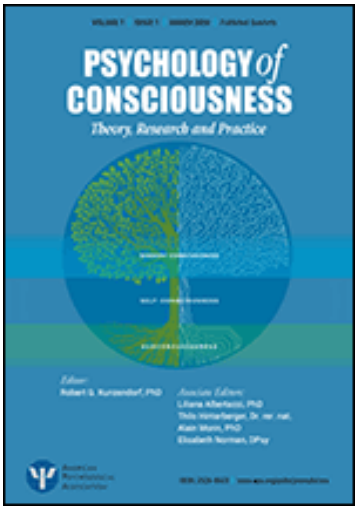

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Mastering the impossible: How an easier-than-expected magic intervention acts as a source of self-efficacy

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ABSTRACT: The greatest achievements often arise from challenging the status quo of what is thought to be possible. These types of achievements require certain beliefs about one's capabilities, but little has been done to explore the value of imaginal self-efficacy sources. We conceptually argue that a potent source of self-efficacy is an actual mastery experience that is also perceived as impossible. As a result, this experience contains advantages of both imaginal and actual success experiences. In part, this result is due to the conscious awareness of social reactions to a seemingly impossible event. Based on this argument, we created a brief arts-based intervention that involved learning a simple magic trick to create an "imaginal mastery experience" and piloted the intervention by measuring its impact on self-efficacy. Our results suggest that the pilot intervention may have enhanced participants' personal self-efficacy. Participants overestimated the difficulty of the trick, while their confidence in performing increased. A thematic analysis on how participants perceived their audience's social reaction revealed that the magic trick involved surprise, curiosity and interest, confusion, and other positive emotions. Psychological theories and directions for future work on developing this pilot intervention are discussed.

What once seemed impossible often becomes the greatest advancement of modern times. Whether it is setting a new world record or technology that surpasses human ability, they all start with a belief in one's capability of transforming the "impossible" into reality. For example, Walt Disney described his work as being "kind of fun to do the impossible" (Walker, 1982, p. 10) when he revolutionized the animation industry, earning a record breaking number of Academy Awards**.** In psychology, the belief in one's capability to successfully carry out certain actions or behaviours is known as self-efficacy (Bandura, 2008). However, the greatest innovations of the future require self-efficacy in achieving something *more* than what has already been demonstrated as possible. They require self-efficacy in one's ability to do something that is not only valuable to society, but also novel in the sense that the achievement borders on the edge of what is currently accepted as possible.

Bandura's model of self-efficacy originates from Social Cognitive Theory, which emphasizes the importance of experiences and the social context in shaping behaviour (Bandura, 2008). However, the model was initially limited as it only accounted for actual sources of self-efficacy, rather than imagined sources. The first of these actual sources from Bandura's model is a mastery experience, where an individual succeeds in new challenges. However, if the novel challenge borders on the edge of what is possible, it is extremely unlikely that the individual can gain a mastery experience for their new goal. Bandura's second source of self-efficacy is a vicarious experience, which is the experience of emulating a role

model. Similar to mastery experiences, this source is absent for goals or challenges that are ambiguous in possibility, unless the role model is imaginary (e.g. fictional characters). Nor does Bandura's third source of self-efficacy, "verbal encouragement and persuasion", explain how people achieve things that were once thought to be impossible, unless the persuader encourages a goal that was *imagined* to be possible. The final source of self-efficacy is by altering physiological and emotional states, which acts as a source of pain or pleasure to motivate successful actions. Although limited, even this physiological source can be influenced by beliefs about what is happening to the body (Olson et al., 2020, 2021). Thus, a limitation of social cognitive theory was that it did not clarify the role of imaginal sources in self-efficacy, such as how (and if) these imaginal sources lead to achievements that lie on the boundaries of what's commonly accepted as possible versus impossible.

To address this limitation, James Maddux suggested a fifth source to be imaginal experiences (Gosselin & Maddux, 2003; Maddux, 2001), which typically involves imagining one's self in hypothetical situations. These imaginal experiences can be derived from actual experiences, such as a vicarious source (e.g., a fictional superhero derived from a real-life role model), verbal persuasion (e.g., a therapist guiding a client's imagination) or an imagined extension of an actual mastery experience (e.g., imagining the ability to invent a hang glider after mastering the psychics of parachutes). While imaginal experiences have fewer limitations (i.e. limited only by imagination), they also tend to have a weaker influence on self-efficacy beliefs than actual experiences of mastery (Williams, 1995). Actual experiences of mastery, however, seem to be the most potent source of self-efficacy beliefs (Maddux, 2001; Williams, 1995). Thus, some combination of both imagined and actual mastery experiences may explain how self-efficacy arises when high-achieving individuals master things that once seemed impossible.

In this paper, we argue that an even stronger source of self-efficacy is an *actual mastery experience* that is also *perceived as impossible*, thus containing benefits of both imaginal and actual success experiences. The benefit of imaginal or impossible elements is in expanding and exploring the realm of what is possible, similar to the role of positive emotions in broadening and strengthening one's psychological repertoires (Fredrickson, 2004). This broadening aspect may also play a role in generalizing to multiple life domains instead of a single, isolated skillset. Meanwhile, the actual success experience provides both intrinsic and social validation, which confirms that the individual is truly capable of transforming imaginal elements into reality. The perception of impossibility is also important in at least two other regards. First is the stark contrast between 1) the initial evaluation of a task being impossible and 2) the subsequent experience of executing the "impossible" task successfully. This forces the individual to challenge prior beliefs about the limits of their capabilities, which naturally leads to wondering what *else* they might be capable of. The second role of perceived impossibility is to provide social validation from the reactions of others. If others *also* deem the task to be impossible, they will react accordingly when seeing the impossible event, thus confirming the successful accomplishment.

Designing an "impossible" intervention

Therefore, to create such an activity that optimally increases self-efficacy, it would require 1) a task that is commonly perceived as impossible (or at the very least, ambiguous in its possibility), 2) an opportunity to receive social validation in the form of reactions that imply the impossible became possible, and 3) the task to be practical enough for participants to successfully learn and accomplish the skill in a reasonable amount of time.

One activity that clearly meets the first two criteria is magic: the art of performing the impossible. The experience of watching magic is a conflict between what we know to be possible and what we directly perceive as impossible (Kuhn, 2019; Lamont, 2017; Leddington, 2016; Parris et al., 2009). Since magic tricks are experienced as both possible and impossible, this allows them to satisfy the first requirement of perceived impossibility. Furthermore, this conflict is also reflected in the experience of performing magic because the performer's secret knowledge asserts the trick to be possible, whereas social reactions to the magic imply that the impossible did indeed become possible (even if only for a moment). As a result, the magician gains the equivalent social validation of achieving the impossible, for a success experience that is very much possible and achievable in the mind of the magician.

To satisfy the practicality requirement, the magic trick in the self-efficacy intervention would need to be

sufficiently simple to be accomplished in a reasonable amount of time. Professional magicians often spend entire careers designing and rehearsing magic performances, creating new secret methods for tricks, and practicing performances for countless hours (Rissanen et al., 2014). However, there is a subset of magic tricks known as "self-working" tricks that require less time to master (Fulves, 1990; Self-Working Magic, n.d.). For these, the magical effect occurs automatically, when simple instructions are followed. Furthermore, the perceived difficulty of learning these tricks is more likely to be overestimated since the actual secret is rather simple. Thus, self-working tricks are ideal for designing a magic-based, self-efficacy intervention that maximizes the chance of participants successfully performing the trick.

Preliminary evidence for why magic might enhance self-efficacy comes from prior studies showing that learning to perform magic can boost self-esteem. Self-esteem increases were observed in studies of children with disabilities (Ezell & Klein-Ezell, 2003; Fancourt et al., 2020; Spencer, 2012), in English language learners[1] (Spencer & Balmer, 2020) and in first year undergraduate students (Bagienski & Kuhn, in press). Themes of pride have also been observed qualitatively from descriptions of discovering secrets to magic tricks (Danek et al., 2014). Furthermore, a systematic review of the research on magic and wellbeing (Bagienski & Kuhn, 2019, 2020) observed that increases in self-esteem and feelings of pride were only present when participants learned to perform magic but no such studies existed on the impact of merely watching magic. While some studies have mixed results, the overall weight of evidence leans toward a positive effect on self-concepts when taking into account the empirical quality of studies. For example, the three studies that failed to find an effect consist of a small sample size of only 11 patients (Kwong & Cullen, 2007), a sample mixed with schizophrenic patients who likely had difficulty discerning the "magical effect" (Sui & Sui, 2007), and one that only measured post-intervention self-esteem and compared magic against an art group (Wiseman et al., 2021), which can confound results considering the existing knowledge-base of many arts elevating self-esteem (Fancourt & Finn, 2019).

Potential pathways from magic to mastery

The mechanisms on how magic enhances self-esteem are not fully understood but one possible pathway is through a generalized self-efficacy that originates from a mastery experiences that is perceived as impossible by others. Since this type of mastery experience has imaginal elements that may broaden one's psychological repertoire, the self-efficacy may expand to other domains beyond magic itself and thus increase one's self-esteem via an overall self-evaluation.

In addition to this, self-efficacy in performing magic may mediate self-esteem if magic is inherently valued by individuals. As described by James (1892), self-esteem arises when one's perceived success in *valued domains* meets the expectation of one's self in that domain (i.e. self-efficacy as a prerequisite for this expectation). Learning magic may be valued at a primitive level as evidenced by experiments in both children and adults, showing that tricks presented with a magical causation were interesting to explore (Subbotsky, 2010). Furthermore, many are driven to figure out how a trick works, which may suggest that learning the secret is valued, and this aligns with research on how people place greater value on things (e.g. secret knowledge) that are scarce (Cialdini, 2007). The idea of magic being inherently valued becomes more apparent when reframing the process of learning magic as "understanding what's possible", which is a domain that humanity must value for the evolutionary reason of constructing an accurate enough reality in order to survive.

The latter aspect of self-esteem arising from meeting (or exceeding) one's expectations is also very likely in performing magic. People tend to set aspirations and expectations of themselves in the realm of possibility, which means expectations of achieving the "impossible" would be low for magic. Thus, at a certain imaginary level, learning to perform the impossible would necessarily *exceed* one's expectations and ultimately enhance both self-efficacy and self-esteem.

The mechanism by which the performance of magic provides social validation to the performer through its social reactions also remains unknown. In this regard, we anticipate that curiosity plays a dual role. Firstly, cu-

[1] While results showed numerical self-esteem increases for all but one student who maintained self-esteem, no statistical significance tests were reported, presumably due to a small sample size of 21 students.

riosity about the trick's secret sends a message to the performer that they executed the trick successfully. Secondly, this curiosity may act as a social reinforcer by being perceived as an interest in learning more about the performer. Furthermore, this type of reaction reflects a social response that cultivates positive social relationships. This well-documented characteristic of positive relationships is when people respond to good events in an active and constructive manner (Gable et al., 2004, 2006), which has even been replicated in new interactions with complete strangers (Kleiman et al., 2015). These active constructive responses are characterized by 1) enthusiasm and 2) encouraging the sharer of the good event to relive that moment, thus capitalizing on associated positive emotions. For magic, the latter part is reflected in curiosity, where the responder genuinely wants to learn more about the good event. In performing magic, the "good event" is the ability to execute the trick successfully, which is shared by performing it. Moreover, the perceived enthusiasm originates from a combination of the surprise that magic elicits (Harris, 1994; Parris et al., 2009; Vidler & Levine, 1980) along with other positive emotions that magic is thought to elicit, such as humour (Leddington, 2020), awe (Bagienski & Kuhn, 2019), and joyous-exploration curiosity (Bagienski & Kuhn, 2019). Thus, this social validation would further reinforce the mastery experience by facilitating a positive relationship between performer and spectator.

The present study

Thus, the current study aimed to primarily test the hypothesis that performing magic would increase self-efficacy by giving the individual a unique experience of mastery. If true, this lends support to the mechanism of self-esteem increases via self-efficacy that is sourced from actual mastery experiences that are perceived as impossible. To further examine whether self-efficacy in performing magic would generalize to other domains, we examined how participants process real life, problem-solving scenarios. In addition, we set out to investigate some of the hypothesized mechanisms. The first was to test the prediction that, for self-working magic tricks, people's expectations of their ability to perform the magic trick are lower (i.e. more difficult) than the actual difficulty of performing the trick. This means that performing magic would exceed initial expectations of one's ability to perform the "impossible" magic trick. Secondly, we conducted an exploratory analysis to investigate the mechanism of perceived social reactions that could act as social validation of the mastery experience. We hypothesized that these reactions to magic tricks would reflect active-constructive responses and contain emotions of curiosity, surprise, and positive emotion.

Methodology

Participants

Participants were A-level[2] students in London attending an open day at the University who were considering an undergraduate psychology degree. All participants were recruited via the university's recruitment team. The final sample consisted of 75 students (9 male, 64 female, and 2 undisclosed genders) with mean age of 17.43 (*SD* =3.46). Participants took part in the study before a presentation on the school's undergraduate psychology program.

Procedure

The magic trick lesson was based on a segment from the magic workshops reported elsewhere that yielded improvements in self-esteem for undergraduates (Bagienski & Kuhn, n.d.). Two tricks were selected and were as similar as possible to minimize confounds. The tricks used the same type of props and had the same magical effect. This magical effect began with the magician holding two long pieces of either rope (or string). He then magically combined the two separate pieces of rope (or string) into one long piece by using a magic gesture or some "invisible" magic dust. Although students learned the same magical effect, the secret method for each group was different (*Professor's Nightmare*, n.d.; Sankey, 2010). This was to ensure performances would yield a genuine reaction from the opposite group, uncontaminated by their audience knowing the secret. Furthermore, we maximized the chance of students having a successful performance by 1) choosing simple, effective self-working magic tricks, and 2) having participants perform tricks for a spectator naïve to the secret method, so they gain social validation of their success. Both the

[2] A-level is the United Kingdom equivalent to high school in America.

performances and lessons were stripped of entertainment and presentational elements (e.g. jokes, stories) to minimize any confounding factors and focus on aspects unique to magic.

An outline of the procedure is shown in Figure 1. Before learning tricks, students first completed baseline self-efficacy measures. Next, they were split randomly into two groups of equal size that were physically separated, with a different instructor for each group. Each group was located at opposite sides of a large lecture theatre during lessons, giving very little chance for students to learn the other group's secret method. After seeing their respective magic trick performed by the instructor, they completed the remaining baseline measures. These consisted of the perceived difficulty of learning the trick, their confidence in being able to perform the trick, and how much they think they would enjoy learning the trick.

After watching the magic trick, participants received the necessary props and were taught only the bare mechanics needed for the trick to be perceived as impossible by others. No other theatrical or entertainment elements were taught (e.g., jokes, stories). Immediately after the group lesson, students were given time to practice, and individual help was given to students as needed. This ensured that every participant understood the trick well enough to perform for the opposite group. Students were also instructed to not reveal the secret to the trick, even if asked. This session lasted approximately 10 minutes.

The two groups were then brought together from the opposite sides of the room by forming two straight parallel lines with students facing each other, such that every student did a one-on-one performance to a student from the opposite group. All participants then took turns performing their magic trick for their performing partner. After all participants performed, they went back to their seats to finish the post-measures. The entire intervention, including questionnaire time, lasted no more than 30 minutes. Procedures and measures were approved by the University's ethics committee.

Measures

All measures and item-wordings for the questionnaires can be viewed in the supplementary material. Students were instructed to only continue measures at the appropriate times as described in the procedure section.

Self-efficacy

To measure self-efficacy, we utilized the Pearlin Mastery scale (Pearlin & Schooler, 1978). The scale measures the extent to which an individual believes that their capabilities regarding life outcomes is under their personal control as opposed to fate or external factors and has been previously used as a proxy measure for self-efficacy (Meinhold & Malkus, 2016). The scale uses a 4-point Likert format ranging from "Strongly Disagree" to "Strongly Agree". For our study, reliability was good for both pre (Cronbach alpha = 0.73) and post (Cronbach alpha = 0.75) measures.

We also included a post-intervention question asking participants to rate on a 5-point Likert scale whether the activity affected their perspective on mastering new skills. The choices ranged from "Greatly changed my perspective in a negative way" to "Greatly changed my perspective in a positive way". If it had affected their perspective, participants were asked to explain how and why in a qualitative, free response question.

Social Problem Solving

To examine generalisability to other areas of life, we utilised scenario tasks from the Means Ends Problem

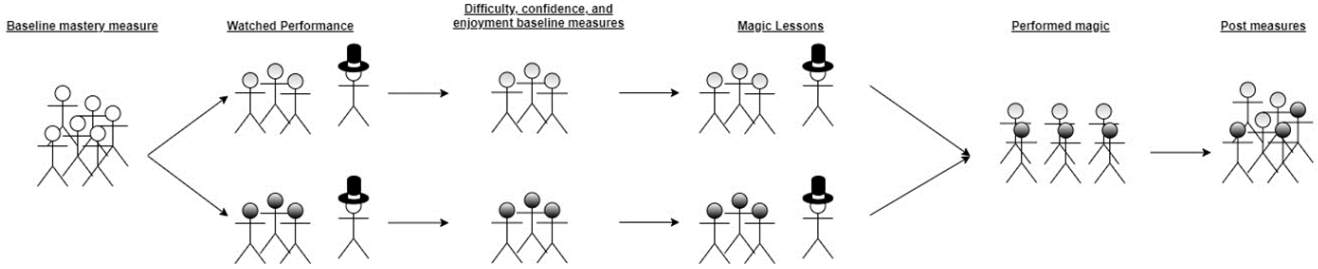

Figure 1. Diagram providing an overview of the procedure, including timepoints where measures were taken. Different shading reflects the two different secrets methods learned by participants.

Solving Task (MEPS, Platt & Spivack, 1975). This task presents a scenario with a problem in second person point of view, along with an ideal outcome. The steps on how to achieve the outcome are omitted and participants are asked to fill in this "middle" part of the story. A total of four scenarios were presented on the questionnaire printout where students wrote their responses. The situations were designed to be of relevance to students about to undergo the college transition. These scenarios were 1) receiving a poor grade on an A-level midyear exam, 2) feeling homesick after starting college, 3) making new friends at university, and 4) a long-distance romantic relationship due to different choices of university. The scenarios were counterbalanced such that each of the four scenarios were present in pre- measure for exactly two of the four conditions. The complete materials for the scenario tasks can be found in Appendix A.

Difficulty, Confidence and Enjoyment

To test our hypothesis that learning to perform magic would exceed initial expectations, we first asked participants about their perceived difficulty both before and after performing the magic trick. The item was rated on a 5-point Likert-type scale. To avoid students accidentally rating the difficulty of figuring out the secret, the item intentionally clarified that they are to rate the difficulty assuming someone was teaching them the trick.

To confirm that perceived difficulty translated to confidence in one's ability to perform the magic trick, we also asked students about their confidence in performing the trick both before and after they performed the magic trick. This item was analogous to the question on perceived difficulty in terms of phrasing and a 5-point Likert-type scale.

To test whether students accurately predict their enjoyment of learning and performing the magic trick, we also asked about their anticipated and actual enjoyment of learning the magic trick. These followed an analogous format as the prior questions on difficulty and confidence. The rationale for this comes from the prolific rule of magicians to never reveal secrets to the magic because it would spoil the enjoyment of wonder and mystery. This rule presumes that audiences may overestimate the enjoyment of knowing the secret. Thus, we wanted to confirm that our participants enjoyment from learning and performing magic would not be undermined by learning the secret to the magic trick. That is, any loss of enjoyment from figuring out the secret would be compensated by the increase in enjoyment from learning and performing the trick successfully.

Social validation of successful performance

To investigate how social reactions to magic might act as validation of the mastery experience, we included an open-ended question asking students to describe their spectator's reaction during the magical moment of the performance.

To further explore the emotional content of this social reaction, the item after the open-ended response instructed students to choose three of 27 possible emotions. The 27 emotions were from Cowen and Keltner's (2017) analysis of emotional states in response to emotionally evocative videos. We chose the emotions from this study because 1) the magical effect was predominantly visual just like Cowen and Keltner's (2017) videos, and 2) the list was broad enough to distinguish various types of positive emotions. We asked the "performers" (rather than spectators) to choose the emotions because the performer's judgement of the social reaction is ultimately what matters most in determining whether they performed the trick successfully, rather than the spectator's actual feelings. In most cases the two are likely identical. However, by asking performers to rate emotions, we avoid confounds from cases where a polite spectator "fakes" a positive reaction that the performer interprets as genuine.

Analyses

Self-efficacy

Repeated measures t-tests were carried out on scores from the Pearlin scale. If one or more question was not answered, that student was excluded from the analysis because scoring is calculated from summation of item scores (Pearlin & Schooler, 1978). If a post measure was missing for the scenario tasks or perceived impact, the participant was excluded for that corresponding analysis because the data would be incomplete since we were comparing change scores before and after the intervention.

For the perceived impact on mastering new skills, a one sample t-test was conducted against the value of 3 (indicating no positive nor negative change). Values above three indicated that learning the trick positively affected the participant's perspective on mastering new

skills whereas less than three would indicate a negative impact. Thematic analysis was used for the free-response question, where two coders independently assigned codes and generated themes. After themes were generated, the two coders reviewed and discussed the themes together before deciding on the final themes.

Social problem solving via MEPS task

MEPS solutions were first transcribed and blinded by a third party so that neither researchers nor coders knew which scenarios were presented before or after the intervention. Next, the main researcher coded all scenarios for means ends as per protocol (Platt & Spivack, 1975), counting the number of discrete steps. An instruction sheet was created to clarify what counts as a discrete step, which was given to a second researcher along with the transcribed scenario responses. There were three coders in total, including the main researcher. If a participant failed to complete one of the scenario tasks, the score was excluded. Inter-coder reliability was estimated using Krippendorff's alpha test (Hayes & Krippendorff, 2007), and these alpha values are the ones used in the results section below. For the Means End Problem Solving scenario scores, the blind codes were revealed only after all coding was completed by all three raters. The mean of the three scores from raters was first calculated for each scenario for the participant. Next, the two scores corresponding to the two pre intervention scenario tasks were averaged together to obtain a final "pre" score for that participant and this was repeated for obtaining a final "post" score for each participant. A paired samples t-test was then conducted to compare baseline MEPS scores to post-intervention MEPS scores. To ensure that scores between each of the counterbalanced conditions were not significantly different from each other, one-way ANOVAs were carried out, separately for pre- and post- scores, with the counterbalanced conditions.

Difficulty, confidence and enjoyment

Independent samples t-tests were conducted for the difficulty, confidence, and enjoyment items between the pre and post scores. To examine the relationship between difficulty and confidence in performing the trick a correlational analysis was performed.

Social validation of successful performance

For the open-ended question on their spectators' reaction, thematic analysis was used once again. The two coders independently assigned codes and generated themes before the coders compared and finalized the themes.

Results

We evaluated the impact of the intervention on self-efficacy and the change in students' perceived difficulty, confidence, and enjoyment. A total of 75 students (64 female, 9 male, 2 undisclosed) participated in the intervention. Statistical analyses were carried out using IBM SPSS Statistics 24 software. A summary of means and standard deviations is presented in Table 1.

Self-efficacy

Pearlin Mastery Scale

We predicted that participant's self-efficacy would increase post intervention. Six participants (5 female; 1 undisclosed) failed to meet inclusion criteria for the analysis. As predicted, results showed that compared to pre-intervention scores for the Pearlin scale (M = 19.80, SD= 3.15), post-intervention scores (M = 20.52, SD = 3.11)

	Time		
	Pre	Post	Mean Difference [95% C.I.]
Pearlin Mastery	19.80 (3.15)	20.52 (3.11)	0.73 [0.32, 1.13]
Means Ends Problem Solving Tasks	2.61 (0.92)	2.61 (0.92)	
Difficulty	2.81 (1.08)	1.81 (1.04)	-1 [-1.26, -0.74]
Confidence	3.21 (1.05)	3.95 (1.20)	0.74 [.43, 1.05]
Enjoyment	3.70 (1.08)	3.78 (1.00)	0.08 [-0.30, 0.14

Table 1. Means and standard deviations for Pearlin mastery scores, and difficulty, confidence, and enjoyment ratings.

were significantly higher after the intervention, $t(68) = 3.60$, $p < .001$, with a medium effect size, Cohen's $d = 0.43$. This suggests that the intervention may have affected self-efficacy beliefs, such that participants had a sense of agency in their ability to master new skills as opposed to external factors deciding what they're capable of.

Perceived impact on mastering new skills

To evaluate whether participants also noticed a change in perspective on mastering new skills, a single sample t-test was conducted after excluding two participants (1 female; 1 undisclosed). The mean score of 3.56 (*SD* = .66) indicated a slight perspective change in a positive way. This mean was tested against the value of three (i.e. no impact) and the result was significantly greater than three, $t(73) = 7.44$, $p < .001$, Cohen's $d = 0.87$. This suggests participants perceived that the intervention positively changed their perspective on mastering new skills.

Thematic analysis for perceived Impact on social problem solving

From the qualitative responses, the resulting codes were condensed to eight unique themes to describe the data via thematic analysis. After comparing and revising themes, the final list of themes in decreasing order of frequency consisted of 1) Perceived difficulty was much easier than initially expected, 2) Success and achievement coming from hard work, practice and persistence despite the struggles, 3) Broadening or expanding of ideas, getting curious about how things are done, and realizing their capacity for their abilities to expand, 4) An optimistic mindset where "anything is possible", 5) Increased self-confidence or self-esteem in their ability to perform the trick, 6) Being open-minded to attempt new things, new ideas, and not doubting one's ability, 7) A problem-solving mindset for critical thinking and breaking down problems into smaller chunks, and 8) Not as easy to perform as expected. The final two only occurred twice and themes with only one occurrence were not counted. The two most prevalent themes, the perceived difficulty becoming easier and success coming from practice or hard work, both occurred approximately nineteen times. The theme of broadening occurred approximately twelve times, followed by an optimistic mind occurring eight times. The Self-confidence and open-minded themes occurred about six and five times, respectively.

Social problem solving via MEPS task

For scenario tasks, eight participants (7 female; 1 undisclosed) failed to meet inclusion criteria. There was low inter-rater reliability (Krippendorff, 2018) between raters for all four scenarios: the long distance relationship ($\alpha = 0.712$), feeling homesick ($\alpha = .658$), receiving a poor mark on an exam ($\alpha = .716$), and making new friends ($\alpha = .723$). One-way ANOVAs did not reveal any significant differences for type of scenario in either the pre measures, $F(3, 63) = 0.59$, $p = .63$, nor the post measures, $F(3, 63) = 1.59$, $p = 0.2$.

The paired sample t-test used to evaluate the generalisability of mastery to other life skills indicated no significant difference for the MEPS task from pre ($M = 2.46$, $SD = 0.88$) to post ($M = 2.61$, $SD = 0.92$) intervention scores, $t(66) = 1.15$, $p = .25$.

Difficulty, Confidence, & Enjoyment

We predicted that from pre to post intervention, the perceived difficulty of magic would decrease, confidence would increase, and that enjoyment would not be spoiled by learning the magic. Furthermore, we predicted an inverse correlation between confidence and difficulty, in line with our prediction that exceeding one's expected ability to perform magic originates from overestimating the difficulty

For the pre- and post-analyses on difficulty, confidence, and enjoyment, two participants were excluded (1 female; 1 undisclosed) for missing data. As predicted, results showed a significant decrease in the perceived difficulty after the intervention, $t(72) = 7.56$, $p < .001$, $d = 0.88$. Similarly, the confidence in performing the magic trick rose significantly after performing, $t(72) = 4.82$, $p < .001$, $d = 0.56$.

To analyse the inverse relationship between perceived difficulty and confidence in performing the magic trick, one-tailed correlational analyses were carried out. For the baseline measures, there was significant inverse correlation between difficulty and confidence in performing the magic, $r(72) = -.38$, $p < .001$. Post measures showed a somewhat weaker but still significant inverse correlation, $r(71) = -.24$, $p < .05$. These correlations were consistent with our hypothesis that students would have less confidence in performing more difficult magic tricks.

The change scores, however, did not have a significant correlation, $r(71) = -.15$, $p = .10$ suggesting that difficulty decreases were not the only factor in increasing confidence.

As for enjoyment, there was no statistically significant change between their anticipated and actual enjoyment of learning to perform the magic trick, $t(72) = 0.75$, $p = .46$.

Social validation of successful performance

From thematic analysis, the codes generated were condensed to eleven unique themes to describe all the data. After comparing and revising themes, the final list of themes were 1) Intense shock and surprise with a few participants experiencing slight surprise, 2) Curiosity, interest, and intrigue, commonly related to how the magic effect occurred, 3) Confusion, 4) Neutral reactions or very little reaction, 5) Sarcastic or faked reactions, 6) Emotions or expressions that communicate a respectful admiration, validation or approval of the magic performance, 7) Energetic positive emotions, 8) Low energy positive emotions, 9) Mystical and magical emotions of awe-like wonder, 10) Uncomfortable emotions, and 11) A desire to see the trick repeated. The most prevalent theme was shock and surprise with 30 students using the words "shocked" or "surprised" to describe the reaction of their spectator. The second most common theme was curiosity or intrigue with 15 students, often using words like "curious", "interested", "intrigued", or wanting to figure out the secret to the trick when describing the reaction. The third most common theme was confusion with 12 students directly saying that their spectator looked "confused". The remaining themes had somewhat similar frequencies with themes ranging from 5 to 12 occurrences among participants, except for three themes that each occurred less than 5 times. Those were sarcastic or fake reactions, uncomfortable emotions, and a desire to repeat the trick.

Due to a clerical error, three of the necessary emotions were not displayed in the survey and replaced by three incorrect emotions that were ultimately removed from Keltner et al.'s analysis (Cowen & Keltner, 2017), which unfortunately undermined the analysis.

Discussion

We designed and piloted a brief magic-based intervention to better understand how self-efficacy is affected by an actual mastery experience that is perceived as impossible. Students learned and performed a self-working magic trick. During both baseline and post measures, we assessed their self-reported self-efficacy, perceived difficulty of the trick, confidence in performing it, and their enjoyment of the intervention. As predicted, self-efficacy increased along with confidence, while perceived difficulty decreased. No change in enjoyment was found, suggesting that participants were accurate in predicting how much they would enjoy learning to perform the trick. Additionally, we used the MEPS task (Platt & Spivack, 1975) to examine whether the perceived enhancement in mastery would generalize to other social contexts. Inter-rater reliability was low for these ratings, suggesting that a more reliable measure would be useful for future studies, and no statistically significant changes were observed in the scenario tasks. Lastly, we conducted a thematic analysis of the perceived social responses to participants' performances to explore the role of social validation in creating a pseudo-imaginal, mastery experience. Overall, results showed that participants overestimated the difficulty of the magic trick, underestimated their ability to perform the magic, and subsequently experienced a stronger belief in their ability to master new skills upon performing the tricks successfully. The thematic analysis on the social validation of the performance revealed that reactions were predominantly characterized by 1) surprise, 2) curiosity, interest, or intrigue, and 3) confusion.

The enhanced self-efficacy indicated by the increase in scores of the Pearlin scale provides preliminary evidence for the mechanism of imaginal mastery experiences affecting self-efficacy, which ultimately enhances one's self-worth (i.e. self-esteem). We used the Pearlin scale for self-efficacy since it measures beliefs about the extent to which one has control over one's life outcomes, and self-efficacy is the belief in one's capability to control or achieve those outcomes.

While self-efficacy does not necessarily lead to self-esteem, the benefits of performing magic on self-esteem improvements have been documented in both disadvantaged children (Ezell & Klein-Ezell, 2003; Spencer, 2012) and first year undergraduate adults (Bagienski & Kuhn, in press).

Others have highlighted that self-esteem is more related to affective variables whereas self-efficacy is more

related to motivational aspects (Chen et al., 2004). Affective components present in magic could very well stem from entertainment elements, such as humour and storytelling, since they share commonalities with the self-esteem improvements observed in other arts interventions (Fancourt & Finn, 2019). However, this confound of similar entertainment elements is unlikely because magic lessons in our intervention were intentionally devoid of these entertainment elements by design to get as close as we could to the core of what makes magic unique. Furthermore, participants were not instructed to include any sort of personal creation in their magic performance. By contrast, motivational elements of self-efficacy are more closely related to the intense curiosity that arises from witnessing an impossible moment — an aspect unique to magic (Leddington, 2016). The experiment was limited in that we did not directly measure self-esteem, which would have helped reveal whether self-efficacy mediates self-esteem in the context learning to perform magic. On the other hand, evidence of self-efficacy playing a mediational role in other contexts is supported by both prior research on self-esteem meditated by self-efficacy in regards to workloads (Molero et al., 2018), and models of self-esteem mediated by emotional and interpersonal self-efficacy (Caprara et al., 2010). This mediational role of self-efficacy on self-esteem, evidence from prior magic studies on self-esteem, and results from the present study altogether hint at the idea that self-efficacy from imaginal mastery experiences in magic may mediate its impact on self-esteem. Thus, while affective components may play a role, our study was the first to investigate this mechanism of self-efficacy driving a potential self-esteem increase by undergoing an actual mastery experience that is perceived as impossible.

Another motivational aspect of this type of mastery experience appears to be the social validation students receive from performing the trick. Despite knowing it was a trick, students obtained a first-hand experience of creating an impossible magic moment for someone else. Similar to how spectators experience a conflict between what they know is possible and what they perceive, our performing participants likely experienced a conflict between what they know to be true (i.e. the trick's secret) and what their spectator's social reaction conveyed (i.e. that the performer did something impossible). This moment is likely short-lived and fades as the spectator begins to rationalize what happened. Nevertheless, the reaction still provides the performer strong evidence that they performed the trick successfully, in at least two ways. First is that the "impossible reaction" suggests that the secret was not discovered, which is commonly viewed as a success in performing magic. The second is on an imaginary level where the "impossible reaction" suggests that something impossible did indeed happen and that the performer was the one responsible for making it happen. The themes from the qualitative data reflect this with participants perceiving reactions to be characterized by surprise, curiosity, interest, and range of positive emotions that include awe-like emotions of being "amazed", amusement, and higher energy positive emotions like excitement. All these emotions could also be reasonably experienced when first seeing or hearing an amazing new achievement for the first time ever. The predominant themes of surprise and curiosity also mirror the interest and enthusiasm of active constructive responses (Gable et al., 2004, 2006) in developing positive relationships (Kleiman et al., 2015), which appear to play an important role in the social validation of their performance success and warrants further research.

Since our research focuses on the performer's experience, the emotions measured have a clear limitation of being a crude observational measure for the *actual* emotions experienced by spectators. The spectators' internal experiences may have been very different than what our naïve performers observed, which limits our ability to draw any conclusions on the genuine emotional experience of watching magic tricks. Furthermore, beginner magicians may not be ideal for creating a magical experience. Thus, future work on watching magic may want to explore how the performer's perception compares to the spectator's actual experience of the trick.

Lastly, our results support the hypothesis that these changes may stem from participants' expectations about the intervention. Participants largely overestimated the difficulty of performing the tricks and underestimated their ability to perform the trick. These two measures were inversely correlated as anticipated. On the other hand, change scores of difficulty and confidence were not significantly correlated. This indicates that the decrease in perceived difficulty was much larger than the corresponding increase of confidence. In part, this could be

due to a negativity bias (Vaish et al., 2008) in self evaluations, where there is more heightened attention on negative self-aspects in performing (i.e. incompetence, a focus on minor performance flaws) than on neutral or positive events (i.e. the decrease in perceived difficulty). Additionally, not all students performed flawlessly, with a minority accidentally revealing the secrets, which could have undermined their confidence in their ability to perform the trick. These imperfect performances may have been the result of the brevity of the intervention which lasted no more than 25 minutes in total, including questionnaire time. Finally, since performances were all done in the presence of other students, standing shoulder-to-shoulder, there are likely group dynamics at play and social comparison biases, which would dampen the increase in one's confidence, particularly for participants who did not perform as well as others. Thus, while the change scores in confidence were not as large, the general inverse correlation between confidence and difficulty was nevertheless present, as observed by examining the baseline and post measures individually.

The importance of overestimating the difficulty, while underestimating one's ability was also reflected in thematic analysis of how the intervention changed their perception of mastering new skills. In fact, this theme was the most frequently cited source in the thematic analyses. The frequency of this theme, however, should be interpreted with caution since the prior confidence and difficulty items may have primed students to respond in this way. On the other hand, it is hard to imagine finding our quantitative result of decreasing difficulty and increasing confidence to persist for other artforms, such as juggling, where the skill might look easier than it is in reality. Overall, this overestimation of difficulty for self-working magic tricks appears to play an important role in magic interventions that should be investigated further. Since we did not directly test perceived "impossibility", future work will need to expand on how this phenomenon relates to perceived impossibility. For example, one might compare magic tricks against a presentation of an impressive artwork and teach participants a simple technique for reproducing it.

Although this pilot intervention suggests it had a positive impact, one of the greatest limitations of our study is the lack of a randomized control group. While a positive response bias is another possible limitation, the increase from pre to post scores on the Pearlin scale suggest that if such a bias exists, it is more pronounced in the post measure and thus, more likely to be either a practice effect, demand characteristic or a genuine outcome of the magic intervention. Considering the intervention elements itself entailed no explicit content related to concepts of self-efficacy, it is unlikely that students were primed for it in post measures. Another possibility is that the higher post scores may simply reflect a momentary increase in positive mood. If so, then at the very least, this intervention could provide a useful therapeutic tool to enhance positive mood. Other limitations include the use of purely self-report measures and convenience sampling of high school students attending an open day. Additionally, the low reliability of the scenario tasks analysis undermines our ability to comment on its generalisability to other domains. Future work ought to utilize measures with greater reliability and if results do not generalize, then the intervention might be improved by adding social elements or perhaps by inviting participants to brainstorm additional areas where they might be underestimating their ability. Lastly, our study is limited in that we cannot discern how much of the impact arose from watching the magic performance, guessing and learning its secret, practicing tricks with others, and/or the actual performance element. If students had correctly guessed the secret, for example, this could have a positive impact as prior research suggests discovering secrets to magic is associated with a release of pride and tension release (Danek et al., 2014).

Therefore, future studies would benefit most from firstly utilizing a comparable control group. An inactive control would be useful for separating out response biases whereas active controls could be helpful in comparing its effectiveness to other therapeutic techniques. Measures of self-efficacy alongside self-esteem would also help clarify whether self-esteem is mediated by self-efficacy. Other useful measures for future studies would be observational or behavioural measures, enjoyment compared to other techniques, and a measure of magic's internal conflict between what one is perceiving and what is known to be possible – for both performer and spectator. As a next step to isolate components of the intervention, future work can take measurements after they learn the secret, and after they practice the tricks, and once more after they perform for each other. Lastly, investigating tricks of varying difficulty could provide

further evidence that the key factor in the magic intervention is an overestimation of the trick's difficulty.

Another potential route for future research is to examine the role of curiosity in motivating students to learn and perform magic, since prior studies suggest watching magic may be useful for learning (Wiseman et al., 2020; Wiseman & Watt, 2020). Ultimately, this could encourage participants to engage or generalize their motivation to subsequent content. For example, if self-efficacy increases because of the magic intervention, then this could be used as an experiential learning moment that is followed by lessons on mathematics, science, dance, or the chosen area of interest.

In conclusion, this brief intervention used self-working magic tricks and the most notable finding was that participant's self-efficacy seemed to arise from overestimating the trick's difficulty and therefore underestimating their ability to have a successful experience performing it. The social validation revealed themes of intense surprise as well as curiosity, intrigue, and confusion. We theorize that this is the result of an actual mastery experience that is perceived as impossible: both initially before the secret is learned and later by their spectator. We hope future research will help clarify and test mechanisms, further explore the unique benefits of magic interventions and ultimately lead to meaningful applications of making the impossible become possible.

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Tactical blinking in magicians: A tool for self- and other-deception

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ABSTRACT: Magicians frequently rehearse their sleight of hand before a mirror in order to gain the perspective of their audience. However, magic instructors often warn that this practice can lead to self-deception, as many novice magicians unconsciously blink their eyes when engaging in deceptive action, thereby blinding themselves to evidence of their proficiency. There are few concrete examples of self-deception in the literature that provide definitive evidence in support of deep self-deception, where a person both knows the truth and pushes that truth outside their consciousness. In the experiment reported here, we attempted to elicit magicians' blinking behavior under well-controlled laboratory conditions and to identify variables that impact a performer's tendency to engage in it. We invited magicians to learn a difficult set of coin magic sleights over the course of a week and to perform the routine in a rehearsal setting (with a mirror) and a performance setting (without a mirror). We quantified blink rates in the videos of these performances. Indeed, magicians were more likely to blink when engaging in deceptive action than when not, and blinking was more prevalent when performing more difficult sleights. However, this tactical blinking was only evident in the performance setting. We suggest that rather than serving as self-deception, tactical blinking may enhance deception of the audience through encouragement of synchronized blinking in spectators. Alternatively, self-deception may emerge later in the learning process, after some basic motor proficiency has been established.

Every few seconds, people blind themselves to the visual world when they blink their eyes. Aside from lubricating the eyes, eyeblinks occur for myriad reasons. While a subset of eyeblinks can be linked to exogenous stimulation (so-called *reflexive* and *voluntary* eyeblinks), others serve a purpose that is unrelated to any stimulus in the outside world. Rather, these *endogenous* eyeblinks seem to index processes of the inner-world associated with cognition (Irwin & Thomas, 2010; Stern et al., 1984). For example, endogenous eyeblinks frequently bookend moments of high cognitive load independently of visual demands (Siegle et al., 2008). As Irwin and Thomas noted, "They serve almost as a mental punctuation mark, signaling the end of one stage of information processing and the start of another…and they occur most often when they will not disrupt information processing" (p. 129). As such, endogenous blinks are strategically, but not consciously, placed so as not to detrimentally impact iconic memory (Thomas & Irwin, 2006) or visual awareness during moments of high information content (Hoppe et al., 2018). Of course, predictions about when and how information will unfold can prove incorrect, leading individuals to edit their conscious experiences in a way that distorts reality.

Magicians are master curators of their audience's consciousness. They choreograph the unfolding of environmental cues so that their audience will attend only to

features supporting perception of the "effect" (i.e., the inexplicable magic experience) and not those that would tip the "method" (i.e., secret actions carried out by the performer). Magicians use all manner of manipulations to control where and when their audience is attending in order to shape their perception of events and the subsequent memories they create (Kuhn et al., 2014). Indeed, this complicated choreography is reflected in the blinking behavior of spectators. Wiseman and Nakano (2016) monitored participants' eyeblinks while they watched video of a magic performance by master magician Teller. After breaking down the performance to note moments of *effect* and *method*, the researchers observed that participants showed high rates of blink synchronization throughout their viewing, but importantly the moments of highest blink synchrony tended to align with the perceived endpoints of magic effects (e.g., "mental punctuation marks") and with moments when secret actions were being carried out. Through effective misdirection, Teller was encouraging the audience to blink at moments where full, vigilant attending could have given away the deception.

Audience blink behaviors can benefit a magician's deceptions. However, a magician's blinking behaviors can serve an alternative purpose that complicates deception. Anecdotal accounts have identified blinking as a potential concern for *rehearsing* magicians. In order to adopt the perspective of the audience, magicians frequently rehearse before a mirror. Sankey (2003) observed that:

> Just as Narcissus became obsessed with his own reflection in the waters and eventually drowned, so too do some magicians succumb to their practice mirrors and come to unconsciously edit their own experience of their sleights, rendering them virtually invisible. How? By blinking. (p. 139)

Through tactical blinking, magicians may be blinding themselves to the efficacy (or lack thereof) of their own sleight of hand. Further, Sankey warned that this unconscious behavior could bleed into their performances, leading to conditioned blinking when the magician carries out a deceptive action.

While this blinking behavior may seem like an irrelevant quirk in a strange subset of the population, we believe it may point to something deeper that has eluded experimental psychologists for the greater part of a century: self-deception. Self-deception has been famously difficult to study. The constellation of definitions for self-deception vary in their specificity and are often hard to operationalize. Chance and Norton (2015) outlined three different definitions that have been adopted in self-deception research. The first, *deflationary* self-deception, is any motivated reasoning in service of positive illusions. It involves phenomena like confirmation bias wherein people selectively attend to evidence that supports their beliefs and ignore (or fail to encode) contradictory evidence. However, this definition does not distinguish between instances where people have processed disconfirmatory evidence and those where they have so effectively filtered their attention that they were not exposed to the disconfirmatory evidence in the first place. For example, by this definition a person who only consumes heavily biased news sources is self-deceiving, even though they may never have encountered information that contradicts their beliefs. The second definition requires that people hold their positive illusion despite clearly being exposed to disconfirming evidence. This definition requires denial of counter evidence, but it could be through a process of discounting. Our biased news consumer could be exposed to credible news elsewhere, yet label it "fake news" so as to maintain their positive illusions. Paulhaus and Buckels (2012) labeled these *soft* versions of self-deception. The final, most stringent, definition requires a conscious false belief that conflicts with a known, but unconscious, true belief. This form of self-deception requires that a person have unconscious knowledge that they actively keep outside conscious awareness (Chance & Norton, 2015). Paulhaus and Buckels called this *deep self-deception*. Sartre (1956) clearly articulated the paradox inherent in deep self-deception:

> It follows that the one to whom the lie is told and the one who lies are one and the same person, which means that I must know in my capacity as deceiver the truth which is hidden from me in my capacity as the one deceived. Better yet I must know the truth very exactly *in order* to conceal it more carefully—and this not at two different moments, which at a pinch would allow us to reestablish a semblance of duality—but in the unitary structure of a single project. How then can the lie subsist if the duality which conditions it is suppressed? (p. 49)

The soft operationalizations of self-deception do not allow researchers to differentiate self-deception from outright lying, yet the bulk of the empirical evidence for self-deception fits into this category (Paulhus & Buckels, 2012). Evidence to support the existence of deep self-deception is scant, as it is difficult to design an experimental protocol that can differentiate between unconscious knowledge and conscious, but actively discounted or ignored, knowledge. The most widely cited evidence to support deep self-deception (and among the first attempts at observing it under well controlled laboratory conditions) comes from Gur and Sackeim (1979). They reasoned that since many people have an aversion to hearing their own voice, they may be more apt to misattribute recordings of their voice to another person. Indeed, while galvanic skin responses demonstrated implicit recognition of their own voice, the extent to which participants erroneously categorized their own voices as those of others mapped onto differences in comfort with self-confrontation. Participants' conscious experience was shaped by their motives, while their unconscious experience was not. Thus, these participants were holding two separate beliefs at the same time, and the belief available to consciousness was the belief that was motivated. While this evidence for self-deception is compelling, it is far from consequential, and its applicability to behavior beyond contrived laboratory settings is unclear.

The other paradigmatic example of self-deception comes from Quattrone and Tversky (1984). They asked participants to immerse their hands in ice water for as long as they could. After baseline measurements were obtained, some participants were told that individuals with cardiovascular weakness, who are often prone to heart attacks, have trouble keeping their hand in ice water for lengthy periods. Other participants were told the opposite: that cardiovascular *health* is associated with low tolerance for cold. Participants' persistence with the task was related to the prompt they received such that those who thought cold tolerance was indicative of good health kept their hands in the water longer than baseline and those who thought it was indicative of bad health withdrew their hands earlier. Pain intensity ratings also mapped onto their beliefs about the diagnostic value of the task. These behaviors suggested that participants were deceiving themselves for fear of the negative health consequences that would be associated with acknowledging (or not acknowledging) the pain they were experiencing. Importantly, fewer than 25% of participants reported actively trying to adjust their behavior from baseline, suggesting that the biasing of behavior was driven by unconscious processes. Despite a variety of controls, it is difficult to rule out impression management as a more parsimonous explanation for the findings of Quattron and Tversky than self-deception (Lewis, 1996; Paulhus & Buckels, 2012).

In light of the limited research to support the existence of deep self-deception, we turned our attention to magicians. If magicians blink to blind themselves to evidence of imperfection in their sleight of hand when rehearsing before a mirror, this would be a powerful and unambiguous proof of deep self-deception. Beyond anecdotal accounts of this behavior, there is good reason to look to magicians for evidence of self-deception. Evolutionary accounts of self-deception often frame it as rehearsal for deceiving others, offering the deceiver an opportunity to improve their skills in deceit (Trivers, 2000; von Hippel & Trivers, 2011). Indeed, there is a modicum of evidence to support the notion that frequent self-deceivers (in the soft sense) are also more effective at deceiving (Lamba & Nityananda, 2014) and influencing (Smith et al., 2017) others (but see Wright et al., 2015). Magicians are in the business of deception and thus may be particularly adept at self-deception.

We invited magicians with varying levels of expertise to learn a series of coin magic maneuvers over the course of a week. We then filmed them performing the routine in a rehearsal setting before a mirror, and in a performance setting before a camera with no visual feedback. Per Sankey (2003), we predicted that participants would be more likely to blink while engaging in sleight of hand during rehearsal before a mirror than during performance before a camera. Further, we predicted that performers would be more apt to blink while carrying out difficult or unfamiliar pieces of sleight of hand than when performing easier or more common sleights. However, the lie detection literature makes an alternative prediction. Leal and Vrij (2008) showed that participant blink rates slow when they are lying, but increase relative to baseline after telling the lie (see also Marchak, 2013). Thus, lie detection research predicts reduced blink rates while magicians are engaging in deceptive sleight of hand.

Method

Participants

Our sample was limited by the number of participants we could recruit in three afternoons of data collection in the field. We recruited 11 magician participants (1 female; M_{age} = 45.45) through word of mouth, social media posts, and flyers displayed at magic shops in and around Chicago, Illinois. All participants were at least 18 years old. Participants' self-reported experience with magic ranged from ½ year to 50 years (M = 21.32), and their areas of focus within magic varied. This project was one in a battery of tasks that the magicians were invited to take part in. This sub-project was presented as a study of rehearsal techniques. We recruited 17 participants in the greater project, but only 11 elected to participate in this sub-project. In exchange for participating in one or more of the project components, participants received a $15 gift card. The protocol was approved by the Carthage College IRB. We report how we determined our sample size, all data exclusions, all manipulations, and all measures used in this sub-project.

Materials and Apparatus

A coin magic routine was constructed by SE and AB, attempting to sample pieces of sleight of hand that varied in their difficulty and ubiquity (see Supplementary Materials for detailed information on the sleights). The routine was performed to the music "Foxtrot" (Chaplin, 1993). We filmed a 9 minute tutorial video, featuring SE, who introduced the 11 sleights (10 of which were critically examined for this experiment). The video showed the complete routine followed by each sleight broken down step by step in detail. The performance by SE is available at https://bit.ly/TacticalBlinking-Performance. The complete tutorial is available upon request.

We supplied both American silver dollars and half dollars, but participants were welcome to use their own coins. The tutorial video demonstrated with silver dollars, but some participants chose smaller coins to accommodate their hand sizes. We also supplied a felt mat that served as the performance space. A large tri-fold mirror was set up during the rehearsal phase. This mirror was removed for the performance phase. Each participant was recorded with a Sunco HD1080P camera, capturing at 30fps, which was placed at the front edge of the performance mat. The music was played through a small, bluetooth speaker. Demographics were collected in a brief survey, and a debriefing survey evaluated whether participants were able to infer the true purpose of the experiment.

Procedure

Participants provided initial digital consent when they enrolled in the project. One week prior to data collection, participants were emailed the tutorial video and a set of instructions on preparing for the session. It was stressed to participants that we were not expecting the routine to be "performance ready" with only one week of rehearsal and that it was acceptable for them to make mistakes. Further, we asked them not to adapt the routine, but to learn to perform it *as taught*. Finally, we provided them with the music to accompany the routine, but stressed that the timing of the coin routine need not match the timing of the music.

Full, written informed consent was obtained at the time of testing. Data collection happened on three different dates in the lecture room at Magic, Inc., a magic shop in Chicago, Illinois. Participants rotated between stations that were devoted to different components of the greater project. If participants took part in all pieces of the project, it took up to 1.5 hours. The order of the tasks was counterbalanced across participants. During the session, we asked the participants to perform the routine four times: twice in a rehearsal setting and twice in a performance setting. The setting in which they started was counterbalanced for each participant. Experimenters played the music for the participants, but did not actively watch as they performed/rehearsed. A crib sheet was provided to remind participants of the order of the phases in the coin routine.

Results

One participant was excluded from analyses for failing to successfully execute any part of the routine. Other participants skipped sleights or sections of the routine. For this reason, all analyses were carried out via logistic linear mixed-effects models, implemented in SPSS (Heck et al., 2012). Linear mixed-effects models are resilient to missing data, regressing across missing values while accounting for individual differences between participants.

Data Cleaning & Coding

Data cleaning and coding were carried out collaboratively by AB and KR. We first independently identified

the video frames that marked the starting point and end point of each piece of sleight of hand in each participant's four attempts at the routine, using agreed upon, consistent visible cues in the performance. These constituted the experimental frames. Originally, the routine included 11 sleights. However, the final sleight in the routine did not include any visible cues that could be used to denote its start. Consequently, it was not included in analyses. After AB and KR completed their coding, the critical points were compared. Any critical point values that differed between coders by more than 30 frames were reviewed and reconciled collaboratively. All critical points that were within 30 frames of each other were averaged to the nearest whole frame number. Frames that fell outside of these critical points served as control frames, when the participants were not engaging in active deception through sleight of hand. We extracted a set of control frames from each video to equal the number of experimental frames (those when sleight of hand was being carried out). To ensure that our control frames were sampled from moments during the performance (and not downtime in between performances), the initial set of control frames were extracted starting after the first sleight in the routine and ending with onset of the last. However, this process did not always generate enough control frames to perfectly balance the number of experimental frames. If additional control frames were needed, they were extracted from the moments just before the first sleight or just after the last sleight in the routine. Because the control frames were not temporally independent from the experimental frames, we randomized the order of control frames before pairing them with experimental frames for each sleight.

AB and KR independently coded every frame of each performance and rehearsal video, noting whether the participant's pupil was at all visible or whether their eyes were closed. In the few instances where participants turned their heads away from the camera, in the absence of cues about the status of their eyes, we defaulted to assuming their eyes were open. We compared initial rates of agreement using Cohen's kappa for nominal variables (Hallgren, 2012). This analysis showed slight coder agreement based on guidelines from Landis and Koch (1977; $\kappa = .10$). Coders agreed on 73.9% of frames. Disagreements were primarily related to the precise timepoints when blinks began and ended. AB and KR reconciled all disagreements collaboratively to establish one fully-coded, agreed upon dataset.

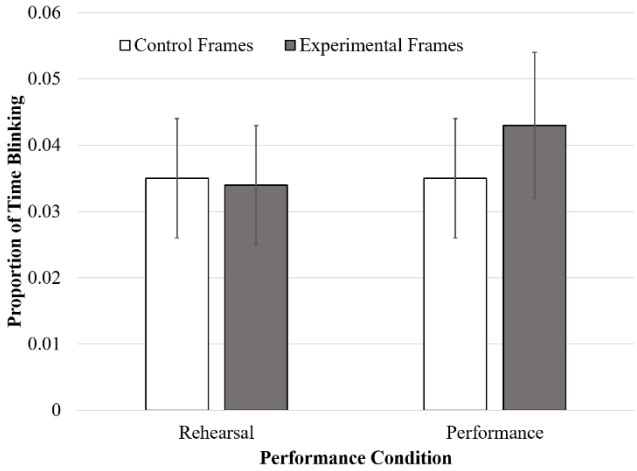

Figure 1. Proportion of Time Blinking as a Function of Performance Condition and Frame Type. Error bars represent +/- standard error of the mean.

Blink Rates

We first analyzed blink rates in a logistic linear mixed-effects model with Performance Condition (performance, rehearsal) and Frame Type (control, experimental) as fixed effects and Subject as a random effect. Figure 1 depicts the estimated marginal means from the model. The model revealed a significant effect of Performance Condition, $F(1, 93388) = 15.41$, $p < .001$, $OR = 1.01$ (95% CI: .93, 1.10), with participant's likelihood of blinking increasing in the performance condition relative to the rehearsal condition. The main effect of Frame Type was also reliable, $F(1, 93388) = 9.69$, $p = .002$, $OR = 1.26$ (95% CI: 1.16, 1.36). As predicted, participants were more likely to blink in experimental frames than in control frames. Finally, there was a significant Performance Condition by Frame Type interaction, $F(1, 93388) = 18.31$, $p < .001$, $OR = .77$ (95% CI: .68, .87). Contrary to predictions, the Frame Type effect was only apparent in the performance condition, $t(93390) = 3.48$, $p < .001$.

In order to explore whether blinking behavior varied as a function of sleight difficulty or sleight commonality, we asked a new group of 18 magicians to complete a brief online survey where they watched the tutorial portions of our video and rated each sleight on its difficulty and frequency of use on a scale from 1-7 (with 7

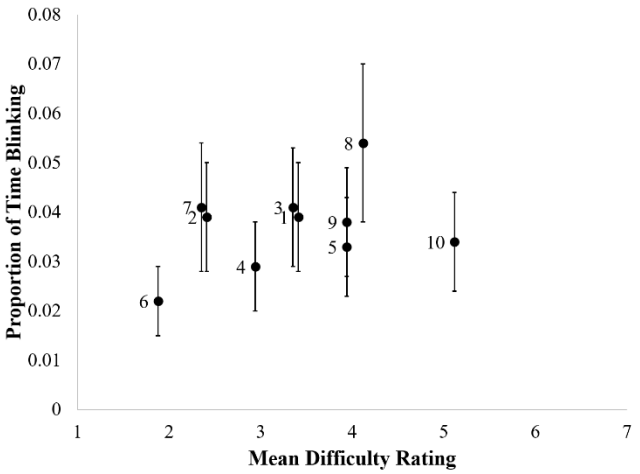

Figure 2. Proportion of Time Blinking as a Function of Mean Sleight Difficulty. Error bars represent +/- standard error of the mean. Seven is most difficult rating on the Likert scale. Data labels represent sleight code numbers (see Supplementary Materials for more detail). [1]Wiped Clean, [2]French Drop, [3]Kort Reload, [4]Toss Vanish, [5]Fingertip Switch, [6]Double Elbow Production, [7]Snap Production, [8]Classic Palm Retention, [9]Shuttle Pass Retention, [10]Classic Palm Click Pass

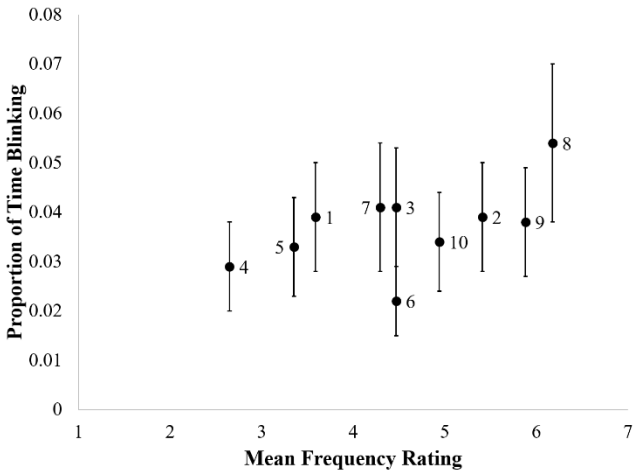

Figure 3. Proportion of Time Blinking as a Function of Mean Sleight Frequency. Error bars represent +/- standard error of the mean. Seven is the highest frequency rating on the Likert scale. Data labels represent sleight code numbers (see Supplementary Materials for more detail). [1]Wiped Clean, [2]French Drop, [3]Kort Reload, [4]Toss Vanish, [5]Fingertip Switch, [6]Double Elbow Production, [7]Snap Production, [8]Classic Palm Retention, [9]Shuttle Pass Retention, [10]Classic Palm Click Pass

being most difficult and highest frequency). Average Difficulty and Frequency ratings were included as fixed effects in two logistic linear mixed-effect models, analyzing blink rates only for experimental frames, with Subject as a random effect. Difficulty was a reliable predictor of blink rate, $F(8, 46688) = 8.16$, $p < .001$, with blink rates increasing with difficulty (see Figure 2). Frequency was also a significant predictor of blink rate, $F(8, 46688) = 6.91$, $p < .001$. However, contrary to our prediction, blink rates increased with perceived frequency of the sleight (see Figure 3).

Discussion

We set out to test anecdotal claims about self-deception in rehearsing magicians. Sankey (2003) noted that magicians frequently develop the habit of blinking as they carry out sleight of hand when rehearsing before a mirror, thereby blinding themselves to any evidence that they are failing to execute their sleights proficiently. Further, this habit could generalize to performance in the real world, thereby providing the audience with a "tell" for when sleight of hand is happening. We predicted that magicians who were asked to learn a new, difficult coin magic routine would be apt to blink more frequently when performing sleight of hand before a rehearsal mirror than before a camera in a performance setting. Counter to predictions from the lie detection literature (e.g., Leal & Vrij, 2008; Marchak, 2013) but in keeping with anecdotal accounts, we found evidence that magicians blinked more frequently when engaging in sleight of hand than not. However, patterns did not perfectly conform to our predictions. The effect was driven primarily by a large increase in blink rates during experimental frames in the performance setting compared to the rehearsal setting. Thus, the eyeblinks may not have served the purpose of deceiving performers about their proficiency. The blinking behavior was, however, related to the cognitive effort associated with the sleight of hand. Blink rates increased when performers were executing difficult sleights. Inexplicably, they also increased when performers were executing common sleights. Since sleight difficulty was only weakly correlated with sleight frequency ($r = .23$), difficulty may have been a more meaningful variable in the current analysis due to its clear relationship with the cognitive effort of the performer.

Our general predictions were derived from assumptions about information content in the visual stream.

Blinks tend to align with moments when there is presumed to be little information content available (Irwin & Thomas, 2010; Siegle et al., 2008; Stern et al., 1984). Consequently, it would be counterproductive for magicians to blink during rehearsal at times when the most useful visual information is present (e.g., during sleights). Any such blinking would lead to a performer establishing metrics about their proficiency that are not driven by their own empirical evidence. They would be engaging in deep self-deception (Paulhus & Buckels, 2012).

If the blinking behavior we observed is not in service of self-deception, what purpose does it serve? Although blinking during performance could act as a "tell" for the audience, it could also offer a nudge to the audience that they have reached a moment when there is very little useful information in the visual stream. It could encourage the audience to blink, thereby blinding *them* to the performer's sleight of hand. In support of this hypothesis, Nakano and Kitazawa (2010) demonstrated that audiences entrain their eyeblinks to those of a speaker so long as the speaker's blinks happen at the end of a thought or during a pause in speech. This entrainment did not occur when participants only heard the speaker's voice. Although our participants were performing without speech, the dynamic construction of the routine may have suggested breaks in the action just as they did in the experiment by Wiseman and Nakano (2016). Performer blinks could further solidify this pacing, encouraging the audience to blink at moments that are opportunistic for the performer's deceptions. Although there is an elegance to this explanation, entrained blinks occur on a brief delay (0.25-0.5 s) relative to the speaker, which might place the blinks after the sleight of hand they are meant to camouflage. However, evidence suggests that the blindness associated with blinking is extended beyond the boundaries of the blink event. Visual sensitivity is reduced for the 100ms before and 200ms after a blink (Volkmann et al., 1980). This may help to counteract the entrainment delay to some extent, in service of the magician's deception.

A more mundane explanation for our outcomes could be that tendencies toward self-deception unfold on a timecourse that differs from that of our experiment. Participants were given a very short period of time to acquaint themselves with the coin magic routine (1 week). Perhaps in the early stages of learning, magicians are more reliant on the visual feedback that comes from the mirror. Perhaps the kind of self-deception that Sankey (2003) described only occurs after a certain level of comfort (and motor memory) has been established for the sleights. It may be the case that the blinking behavior we observed in the performance condition would also appear in the rehearsal condition after the magicians have had more time with the routine. Future research could include more fine grained manipulation of the learning phase to explore how these eyeblink tendencies develop over time.

The ecological validity that comes with experiments of this kind is often accompanied by limitations in experimental control. During debriefing, we divulged the true purpose of our experiment to participants. Although we asked them not to disclose this information to other magicians who may participate in the study, it is possible that they may not have heeded our request. Knowledge of the hypothesis could have impacted participants' eyeblink behaviors, especially in the rehearsal setting where they had constant visual feedback to remind them of their eye movements. However, in our debriefing survey, no participants correctly identified the hypothesis we were studying or the subject of our investigation (i.e., eyeblinks).

The demands placed upon participants in this study were substantial, as they had to spend time prior to their lab visit learning to perform the coin routine. This meant that we were only able to recruit a small sample of participants. There are few demographic data available for the magic community. Our sample may not have been representative of the greater population of magicians. For example, our sample contained only one female magician. (Although we may have over-sampled female magicians based on the demographics reported by Nardi (1988), who estimated that females make up only 3-7% of magicians.) Despite the small overall sample size, our design was much like that of a traditional psychophysics experiment where a large number of samples were taken from a small group of participants. On average, we collected 9339 video frames from each of our 10 participants.

In short, while our experiment did not produce strong evidence for deep self-deception, it did demonstrate tactical blinking that is meant to impact either the awareness of an audience or the awareness of the per-

former. As masters of consciousness manipulation, magicians are a fruitful source of both methods in the study of consciousness and insights into how subtle cues can shape our experience of reality. Although our experience of the world seems continuous and stable, the outcomes reported here serve as another reminder that this inner simulation of the outside world is illusory. In *Phaedrus,* Plato (1952) considered how people classify continuously variable organisms (and objects) into *kinds*, "carving nature at its joints" (265e). Modern biology has demonstrated that the "joints" of nature are illusory, as humanity takes a snapshot of organisms at one point in their continuous evolution. The same might be said about how consciousness attempts to make sense of the dynamic, continuously changing states of the world. Our experience is broken up by eye movements and blinks, yet we construct an inner simulation that does not include these constant disruptions. Top-down processes must intervene to "fill in" the incomplete information about the visual world. The techniques of magicians manipulate the processes by which information is extracted from the world and organized in this inner simulation. It remains an open question to what extent magicians may be fooling themselves through the same techniques that they use to fool others.

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Kaitlyn Richardson is now at the University of Nebraska-Lincoln.

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Supplementary Materials

List of Sleights, Mean Difficulty Ratings, Mean Frequency Ratings, and Sleight References

Sleight Number	Sleight	Mean Difficulty	Mean Frequency	Reference
1	"Wiped Clean"	3.41	3.59	"Wiped Clean" from Ammar (1991; p. 48)
2	French Drop	2.41	5.41	"The French Drop (Le Tourniquet Vanish)" from Bobo (1966; p. 37)
3	Kort Reload	3.35	4.47	"L'Homme Masque's Coin Load" from Minch (1999, p. 125)
4	Toss Vanish	2.94	2.65	A variation on the last coin vanish in Slydini's "One Coin Routine" from Fulves (1976, p. 70)
5	Fingertip Switch	3.94	3.35	Unpublished sleight by Shawn Eric
6	Double Elbow Production	1.88	4.47	A variation on the productions in Slydini's "One Coin Routine" from Fulves (1976, p. 70)
7	Snap Production	2.35	4.29	"Snapping the Halves" from Kaufman (1994, p. 81)
8	Classic Palm Retention	4.12	6.18	"Standard Vanish" from Bobo (1966, p. 22)
9	Shuttle Pass Retention	3.94	5.88	"The Shuttle Pass" from Kaufman (1985; p. 10)
10	Classic Palm Click Pass	5.12	4.94	"The Click Pass" from Bobo (1966, p. 14, Method b.)

Note. A video performance of this routine by Shawn Eric is available at https://bit.ly/TacticalBlinking-Performance.

Could it be Proto Magic? Deceptive tactics in non-human animals resemble magician's misdirection

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ABSTRACT: In the last decade, the study of magic has started to gain the attention of the psychological sciences (Kuhn, 2019; Tompkins, 2019). Psychologists study magic to further our understanding of human cognition including perception, memory, and consciousness. Here, we explore the conscious elements that might make magic unique to humans, such as the experience of wonder and disbelief at the unexpected. We discuss the tactics used by cognitively advanced non-human animals such as apes, corvids, and cephalopods to deceive conspecifics, and consider the parallels between their techniques and the ones used by magicians to make their audience experience the impossible. We also discuss the social dynamics of magic performance, explore the similarities and differences of human and non-human social interactions, and discuss play behaviour in non-human animals. We argue that apes, corvids, and cephalopods might be ideal candidates to start a comparative science of magic, as they appear to naturally exploit analogous blind spots in perception and attention, as well roadblocks in memory, mental time travel and perspective-taking. We highlight the potential of this new and exciting line of research that unlocks alternative avenues for inquiry and investigation. The application of magic to comparative psychology might reveal several interesting psychological constraints across diverse animal minds and offer potential candidates for questions about consciousness.

The psychological study of magic effects has fascinated psychologists for decades, with some of the earliest investigations of magic dating back to 1894, when Alfred Binet presented his psychology of prestidigitation. More recently, the application of magic and the mechanisms that it exploits have been used to gain a better understanding of the constraints on human cognition and consciousness. The investigation of such intricate techniques of deception has already started to yield interesting results on the human experience of sleight of hand (Barnhart & Goldinger, 2014; Phillips et al., 2015), misdirection (Kuhn et al., 2008, 2014; Otero-Millan et al., 2011; Thomas et al., 2018), and choice forcing techniques (Pailhès & Kuhn, 2020b, 2020a). Moreover, interest in magic has also piqued amongst comparative psychologists, where magic effects are being used to compare how other taxa experience these intricate techniques of deception (Garcia-Pelegrin et al., 2021; Schnell, Loconsole, et al., 2021). The use of magic effects provides interesting methodology to explore how animals experience the world around them, and whether this is analogous to the human experience of magic (Garcia-Pelegrin et al., 2020). Magicians use these techniques of deception to elicit wonder and amazement in their audience by capitalising on specific aspects of their audience's phenomenal consciousness such as metacognition (i.e., how did the mentalist know what I was thinking?), mental time travel (i.e., is what I remember what actually happened, or was I tricked in some way?), as well as reflections about self (i.e., but I chose the card myself, how can the

magician know which card I picked?). The question of whether animals are capable of such an intricate experience when observing magic is a complicated one in principle. Traditionally, whether non-human animals have such a level of consciousness is impossible to test in the absence of agreed behavioural markers of non-linguistic consciousness (Boly et al., 2013; Clayton & Dickinson, 1998, 2010; Griffiths et al., 1999). Indeed, the lack of linguistic hallmarks hinders our ability to attribute dimensions of consciousness to animal behaviours. However, the combination of behavioural, cognitive and neurological criteria for conscious experience displayed by some animals grants insight into the possibility of consciousness in non-human minds (Birch et al., 2020).

While the application of magical frameworks to animal behaviour and cognition is relatively new, some researchers, perhaps unintentionally, have been utilising magic effects as a methodological tool for some time (e.g., Bräuer & Call, 2011; Nickerson, 2020; Pattison et al., 2010; Taylor et al., 2012). For instance, violation of expectation paradigms, in which a subject is presented with an unexpected outcome that they are unlikely to anticipate, have been extensively used in comparative cognition (Winters et al., 2015). Such a premise is directly comparable to magic, given that the methodology of both magic and violation of expectation paradigms rely on producing unforeseen events to the naïve observer, and aim to elicit enhanced reactions (i.e., long looking time) at witnessing the unexpected. An example of magic being used as a methodological tool comes from Bräuer and Call's Magic Cup experiment (Bräuer & Call, 2011). To investigate object representation in great apes and dogs, Bräuer and Call used a violation of expectation paradigm by presenting their test subjects with a "magic" cup that has a false bottom. This facilitated the discrete switching of objects inside the cup and thus, from the perspective of the subject, the object appeared to magically transform into another form. This apparatus closely resembles a device known as the Okito box *(See Figure 1)*, which facilitates a well-known magic effect in which coins inserted inside a cylindrical metal box magically vanish and reappear at the will of the magician. Given the plethora of accounts that solidify the effectiveness of magic effects in humans, such effects might also prompt the comparison of analogous behaviours and the necessary underlying cognition in non-human animals (Garcia-Pelegrin et al., 2020). Following this line of thought, comparative psychologists have recently started making the move beyond using magic exclusively as a methodological tool to investigate if similar responses can be provoked in non-human animals, and whether non-human animals can utilise analogous methodologies of misdirection to their advantage (see Garcia-Pelegrin et al., 2021; Schnell et al., 2021).

Deception for entertainment purposes

Magic is often described as deception, indeed even in our own published work we have used wording such as: 'techniques of deception' or 'deceive their audience'. This is because the tactics used by magicians when 'fooling' spectators unswervingly manipulate them into seeing, hearing, thinking, and even remembering the events of a magic effect, not as they truthfully occurred, but as the magician wants them to be perceived and remembered. We define magic here as *"the intentional use of deception for entertainment purposes"*. On the intentional use of deception, we would like to raise the point that magic is comprised of specific tactics of attentional, perceptual, and memory control purposely created to mislead the spectator without revealing the methodological intricacies used to achieve such an effect. Certainly, the comparison between a magic effect and any other deceptive action is understandable. However, we specify "entertainment purposes" to highlight the fact that magicians create their effects for performance purposes only; this is an integral part of experiencing magic as a spectator. Notice that spectators of magic performances react differently when observing magic compared to when experiencing other deceptive actions such as lying. Indeed, lying is often in the arsenal of a magician, as they will frequently tell their audience that they are performing a particular action when, in fact, they are not really performing it, or will encourage the audience to infer an erroneous belief about a particular event. If similar situations were translated to other scenarios within human society, one can be sure that the reaction of the 'duped' counterpart who is aware of being cheated would not be of awe and astonishment but of anger and retribution. As pointed out by Kuhn (2019), experiencing straightforward deception does not seem to elicit the same reaction that being "fooled" by magic does. This might be because there are several factors involved when experiencing

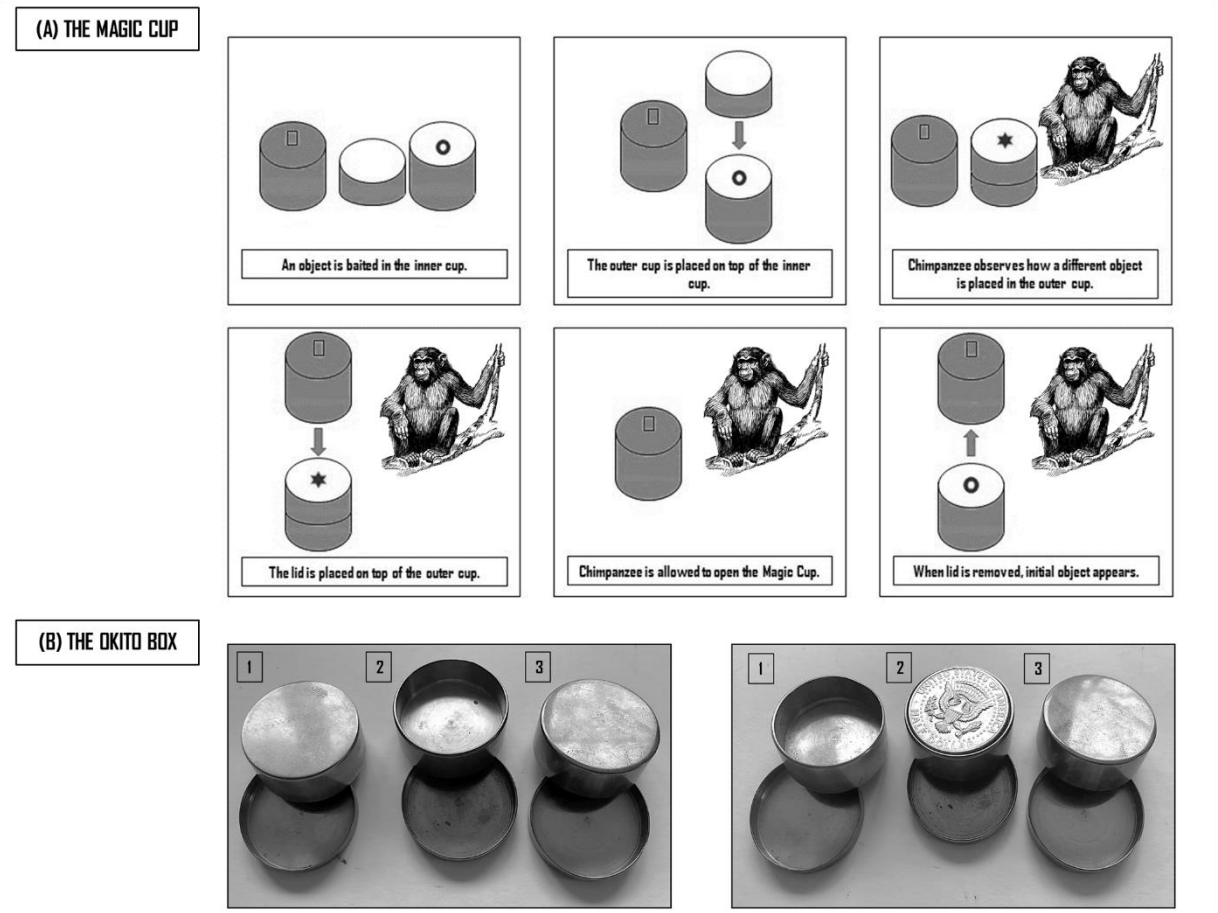

Figure 1. (A) The Magic Cup Apparatus by Bräuer and Call (2011) and **(B)** Three different Okito boxes: **(1)** Okito box with space for several coins, **(2)** Okito box with space for several coins on one side and a single coin on the other, and **(3)** solid Okito box with no space for coins. See extra materials for an example of an Okito box effect.

magic effects that are not inherent in deception. For instance, in most magic effects the risks of the deception are lower or non-existent. The magician might make your coin disappear, but it is implied in the spectator-magician relationship that the coin will be returned at the end of the effect. It is the "magical" return of the coin that completes the effect in most cases. Indeed, it is the existence of the relationship between the spectator and the magician that marks the greatest differentiator between magic and other kinds of deception. Magicians are entertainers, benevolently utilising techniques of deception with the aim of producing enjoyable experiences of awe and amazement in their audience. Thus, ultimately most magician-spectator interactions will culminate in an enjoyable experience for the "fooled" spectator. This cannot be said for other forms of deception like con artistry, in which the con artist will egocentrically disregard how their actions will affect the "mark". Moreover, most spectators make an active choice of experiencing magic with full knowledge of the deception about to take place. Indeed, it might be the sheer curiosity of whether one can perceive such manoeuvres that attracts some of the members of the audience to a magic show. Such complex intricacies, which stem from the ever-present performative aspect of magic, might be uniquely human given they require not only complex cognitive abilities but also consciousness at its core, thus, making it harder for animal researchers to reliably test whether such interactions are analogous in non-human animals.

While it is difficult to deny that the entertainment element of magic is a keystone of the human experience, it is also difficult to deny some of the parallels that the art form has with less reputable activities such as pickpocketing and con artistry. See for example, an act by

Apollo Robbins, a renowned Las Vegas performer who often uses misdirection techniques to pick pocket naïve spectators. Unquestionably, such techniques can and are often used for more nefarious outcomes than to entertain a paying audience. A compelling case could be made that such techniques of deception used for magic effects stem from its more morally questionable relative, the con artist. The first-ever magic trick in recorded history has been argued to date back to ancient Egypt 2500 B.C., in the walls of a burial chamber in Beni Hasan, where two men are depicted performing what is suggested to be a cups and balls effect (Christopher, 1996) *(Figure 2)*, yet rudimentary misdirection techniques can be found in non-human primates such as our closest relative, the chimpanzee *(Pan troglodytes)* (de Waal, 1986)). Therefore, it is unlikely that such tactics evolved for the purpose of entertaining conspecifics, but rather that the tactics often used to trick and deceive others were repurposed to astonish and amaze them instead.

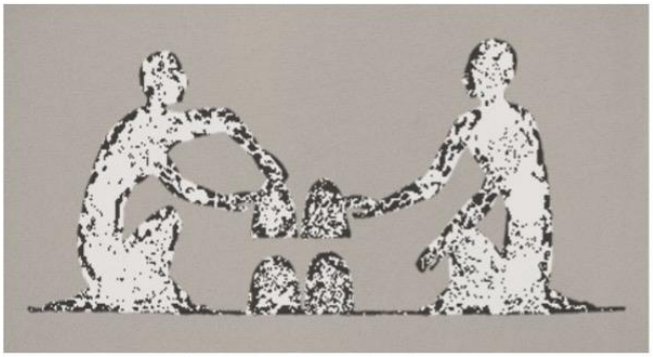

Figure 2. Recreation of Egyptian painting in Beni Hasan. A painting on the walls of a burial chamber in Beni Hasan (Egypt) dating back to 2500 B.C, is said to depict a magician performing a cups and balls effect – a well-known effect in which a ball will be hidden inside one of a set of two upside-down cups and the magician will make the ball appear in different locations at will.

Misdirection in the animal kingdom

"Imagine this; you are at a party having a drink at your table when a man in a white shirt and rolled-up sleeves introduces himself as a magician. He makes eye contact and asks you to choose a card, emphasising the fact that you are free to choose whatever card you want, and gives you a chance to change your mind and choose a different card if you need to, but you stick with your first choice. The magician asks you to sign the card and place it on top of the deck. As soon as you comply, the magician takes the deck with both hands, squares the cards, and then proceeds to flamboyantly cut the deck in front of you with one hand, an impressive feat of "cardistry" for someone not used to seeing ornamental ways of shuffling a deck of cards. Following this, he tells you that your card is "lost" in the deck whilst implying that it would be an amazing feat if he could magically make the card jump from the middle of the deck to the top. You agree that it would be impressive so the magician proceeds. However, when he snaps his fingers and shows you the card at the top of the deck, it is not the one you signed. The magician looks at you confused and then, suddenly, he smiles and mentions how sometimes the card jumps too high and misses the top of the deck. He then points at the top of his ear where a rolled-up card is resting. Even though you already know that it is going to be yours, you feel astonished when he unrolls it and presents the card with your signature. That was magic!"

Without revealing much about this effect, there is an important methodological aspect that is interesting. Evidently, at some point during the effect, the magician seized the card you signed, rolled it up and placed it behind his ear without you noticing. This was done by offering you (the spectator) something else to focus on, thus purposefully redirecting your attention towards the desired object (i.e., the deck of cards being cut with one hand) and away from the deceptive one (i.e., the magician rolling the card and placing it behind his ear). While this may be a complex procedure, it is, by no means, unique to humans.

Chimpanzees (*Pan troglodytes*) and baboons *(Papio cynocephalus)* can divert the attention of others towards a desired object by actively manipulating their own attention (i.e., looking somewhere else and avoid glancing at the direction of the desired object) (Whiten & Byrne, 1988). Furthermore, non-human apes have been observed redirecting the attention of other apes by looking towards a particular object or place, thus actively sending the "mark" off course from a desired item (de Waal, 1986). These examples suggest that some non-human primates naturally exploit the cognitive constraints of their conspecifics by using misdirection. It is thus likely that such an ability evolved to exploit our primate relatives rather than astonish them with unexpected experiences. Even though chimpanzees live in close societal

ecosystems (de Waal, 1986), deceptive behaviour in chimpanzees is rare, nevertheless, deception is a characteristic trait of the primate behavioural repertoire. Deceptive behaviour, however, is not confined to the primate lineage; it extends to other taxa as well. For example, some octopus species can mimic inedible or venomous animals to potentially deceive predators. These octopuses can disguise themselves as marine sponges (Hanlon et al., 2008), lionfish, and banded sea snakes (Norman et al., 2001). Birds are also known to perform diversionary displays to alter a predator's behaviour. For example, some ground nesting birds perform the broken wing display, in which they will feign an injured wing in order to lure the predator towards their location and away from the nests (Gómez-Serrano & Valenciana-Vaersa, 2018), or to avoid predation altogether (Armstrong, 1949). In the wild, not all deception is used to mislead potential predators. Indeed, deceptive techniques may also be used on conspecifics. For example, dolphins, large-brained marine mammals that possess complex cognition and evidence of self-recognition (Janik, 2015; Kuczaj et al., 2009; Marino, 2004; Morrison & Reiss, 2018; Reiss & Marino, 2001; Singer & Henderson, 2015), have been observed employing diverse tactics of deception and attentional control to mislead conspecifics (Connor & Mann, 2012). For instance, Kelly, a female bottlenose dolphin *(Tursiops truncates)* regularly participated in dolphin shows whereby she was trained to retrieve objects that had been thrown into her pool and return them to the trainers to receive a reward. Kelly soon begun to collect random objects left behind by some spectators and hide them inside a sunken box in her pool. She would later retrieve these random objects and hand them to the trainers during the show to receive more rewards. The interesting case of Kelly is that she only hid and retrieved the spectator's objects from the box when the other dolphins were not paying attention to her behaviour. Her 'secretive' manner raises the possibility that Kelly was considering the attentional state and perspective of her conspecifics and using that knowledge to her advantage (Kuczaj et al., 2001). However, while deceptive behaviour might be intricate, the use of deceptive actions to mislead others does not consequently demand sophisticated cognitive ability such as perspective taking for its production. The deceptive response of an animal might just be a product of simpler cognitive mechanisms such as conditioning or a genetically determined behavioural action (Mitchell, 1986; Mitchell & Thompson, 1986). At the pinnacle of cognitively demanding deceit stands the ability to transmit misinformation to alter another animal's behaviour in a specific context that misleads the other individual. This ability, known as tactical deception, has been linked to complex cognition because it is thought to be governed by the capacity to infer that the perspective of the target individual (i.e., the individual that is being deceived) is different from one's own perspective (i.e., Theory of Mind) (Byrne & Whiten, 1985).

Premack and Woodruff coined the term Theory of Mind upon the observation of the deceitful tactics that Sarah, a chimpanzee in David Premack's psychological laboratory, would inflict on her trainers. Sarah was subject to a dilemma in which if a kind trainer would find a hidden banana, she would share it with her, whilst if a different trainer would find it, she would not share the fruit with the chimp. Interestingly Sarah would behave by either directing the kind trainer to the banana or trying to misdirect the selfish trainer's attention away from the banana's location. This seemingly intricate behaviour led Premack and Woodruff to infer that the chimpanzee was altering her actions in reference to the trainer's intention, and thus Sarah possessed the ability to infer them (Premack & Woodruff, 1978; Woodruff & Premack, 1979). However, this interpretation remains contentious as the behaviour elicited can be easily explained by simpler associative learning processes (Savage-Rumbaugh et al., 1978). Even Premack and Woodruff, in later contemplation of chimpanzee behaviour, admitted that they might have prematurely concluded sophisticated inference ability (Premack, 1988). Indeed the whole premise that chimpanzees possess a sophisticated Theory of Mind, akin to humans, is highly debatable as apes are unable to pass other hallmarks of Theory of Mind including (i) desire state attribution such as understanding the epistemological features of visual perception (Povinelli et al., 1996), (ii) attributing knowledge to others (Povinelli et al., 1994), and (iii) nonverbal false belief tasks (Call & Tomasello, 1999). The conflicting results in the Theory of Mind literature has led researchers to infer that chimpanzees might not have a belief-desire understanding but more of a perception-goal one (Call & Tomasello, 2011). While the degree of Theory of Mind embodied by chimpanzees is still a topic of much debate, their use of

deceitful tactics, alongside their propensity to create temporary and long term alliances or "friendships" (Silk, 2002), led Whiten and Byrne to coin the term Machiavellian intelligence (Whiten & Byrne, 1988a). Specifically, in the Machiavellian intelligence hypothesis, heightened deceptive abilities and social cognition in hominids are suggested to be an adaptation of social complexity (Whiten & Byrne, 1988b). It proposes a runaway positive feedback loop in which the social competition between conspecifics elicited an increase in intelligence in the primate lineage (Byrne, 1996).

Corvids, large-brained birds in the crow family including jays, ravens, and magpies, are also known for their deceitful behaviour. They often steal food from conspecifics as well as other species and have been shown to flexibly alter their pilfering tactics by adopting different thieving behaviours dependent on whether they are stealing from a conspecific or a more dangerous species like a wolf (Bugnyar & Kotrschal, 2002). Moreover, pilfering corvids will also adapt their thieving tactics in reference to the identity of the cacher observing them pilfer, by staying away from the caches made by a more aggressive dominant cacher, but readily searching the caches made by a less aggressive but still dominant observer (Bugnyar & Heinrich, 2006). Furthermore, this family of birds can alter their caching behaviours depending on the conditions they predict will be present when they come to recover their caches in the future (Clayton et al., 2005), and this includes securing their caches from potential pilferers who may steal the caches at a later date. These cache protection tactics might be intrinsic for the success or failure of the retention of the cache as corvids can remember the cache location that they have seen others make and attempt to pilfer those regularly (Shaw & Clayton, 2012; Watanabe & Clayton, 2007).

Caching behaviour in corvids is optimized through complex memory processes, namely mental time travel – a capacity that was once thought to be unique to humans (Suddendorf & Corballis, 1997, 2007; *but see* Corballis, 2013; Boeckle et al., 2020). Mental time travel is the ability to recollect episodic memories (i.e., unique past memories based on what happened, where and when) and imagine possible future events with strong links to the human conscious experience (Nyberg et al., 2010). However, given the lack of non-linguistic markers of consciousness, the work in animals on episodic memory has focused on developing behavioural criteria for this capacity, under a new nomenclature (episodic-like memory (Clayton & Dickinson, 1998; Griffiths et al., 1999)) which does not include aspects of phenomenal consciousness that play a crucial role in humans (namely autonoetic consciousness – awareness of authorship of memory, and chronesthesia – awareness of the subjective aspect of time (Jelbert & Clayton, 2017; Klein, 2013; Osvath, 2016; Templer & Hampton, 2013). California scrub-jays *(Aphelocoma californica)* show the strongest behavioural evidence of episodic memory, they recollect what they cached, where they cached it, and when and discriminately retrieve items based on these factors (Clayton & Dickinson, 1998). Caching decisions are also based on future planning abilities because jays can make provisions for a future need (Raby et al., 2007), and can do so independently of their current motivational state (Correia et al., 2007).

Alongside this, corvids keep track of who is watching while they cache and what the observer might know about their cache location; and adjust their cache protection strategies accordingly (Bugnyar & Heinrich, 2005; Clayton et al., 2007a; Dally et al., 2006). When observed by competitors, they use a combination of cache-protection strategies to deprive rivals of visual or acoustic information that might reveal the location of the cache (Dally et al., 2006; Emery et al., 2004; Shaw & Clayton, 2013; Stulp et al., 2009). For example, ravens and jays preferentially cache in shaded sites or behind barriers to reduce the quality and transfer of visual information to potential thieves (Bugnyar & Heinrich, 2005; Dally et al., 2005; Legg & Clayton, 2014), and have been reported to actively misdirect onlookers away from food sources (Bugnyar & Kotrschal, 2004). Jays also prefer to cache in quiet substrates to conceal auditory information, particularly when a competitor cannot see them but is within earshot (Shaw & Clayton, 2013). In addition to manipulating the sensory access of their competitors, jays also retrieve food from old sites and re-cache in new sites once the competitor has departed, but impressively, if, and only if, the cachers have had prior pilfering experience (Emery & Clayton, 2001). These tactics will also flexibly change depending on the observer. Jays will not alter their caching behaviour if the bird observing them is a mate with whom the cache will later be shared. Moreover, if they are being observed by a competitor, jays adjust their cache-protection strategies in response to the

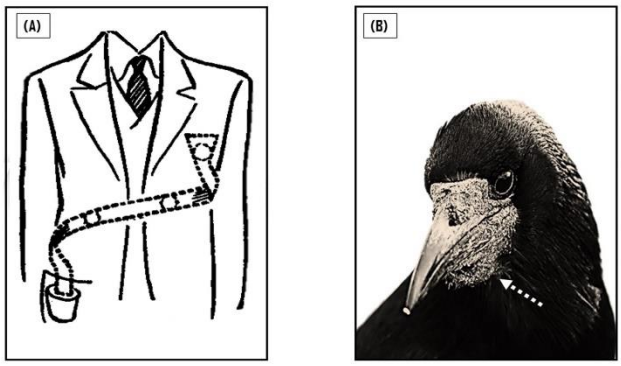

Figure 3. The false pockets of magicians and corvids. **(A)** An illustration of a magician's false pocket and **(B)** a rook (*Corvus Frugilegus*) concealing food in its throat pouch.

status of the observer, i.e., if the observer is subordinate or dominant (Dally et al., 2006). The flexible use of these deceptive tactics in reference to the observer and the experience of the perpetrator (i.e., whether they have had experience pilfering others or not) suggests that some corvids not only appear able to consider the perspective of others, but might also be projecting their own experiences onto them (Dally et al., 2010). The ontogeny of this deceptive behaviour in corvids deserves further exploration as, aside from the role of experience (Clayton et al., 2007b; Emery & Clayton, 2001), little is known regarding how corvids acquire these intricate methodologies and the cognitive processes that underpin their development.

Akin to jays, magicians often change and flexibly adapt their routines in response to the observer and will use similar methodological techniques to the jays to trick the spectator (Clayton & Wilkins, 2019; Garcia-Pelegrin et al., 2020). Indeed, concealing visual and auditory information to spectators (also known as *Masking*) are imperative techniques in misdirection that are regularly used by magicians in a wide range of effects (Kuhn et al., 2014). Moreover, while a magic effect might be perfectly rehearsed, the social and environmental components in which this effect will be enacted will always be outside of one's control. As such, the ability to be flexible with the strategies and methodologies gained by prior rehearsals of the effect grants the magician control over the situation by not making an effect solely reliant on the environmental context in which this is performed. Furthermore, consistent with the caching strategies employed by jays, magicians usually avoid repeating the same effect twice because the attention of the spectator might be more difficult to control the second time around. Therefore, if asked to repeat a particular effect by the audience, magicians often employ different methodological manoeuvres to arrive at the same outcome so as not to compromise the prior effect performed.

As previously outlined, there is often a need for corvids to protect their caches from the possibility of theft (e.g., Bugnyar & Kotrschal, 2002; Grodzinski & Clayton, 2010). These birds utilise intricate and highly elaborate cache protection tactics comparable to the deceptive strategies employed by magicians. For example, corvids can make genuine caches amongst fake caches, inserting the food item discretely during multiple bluff caching events, which makes it difficult for the observer to trace the event (Dally et al., 2006). Correspondingly, moving an object in quick motions to make it harder for the spectator to track is one of the central techniques employed in the cups and balls routine – a well-known effect performed by most magicians in which a ball will be hidden inside one of a set of two upside-down cups and the magician will make the ball appear in different locations at will. Moreover, corvids conceal items in their throat pouch, akin to a magician's use of false pockets *(See Figure 3)* and will manipulate food items within their beak similar to sleight of hand techniques performed by magicians (Clayton & Wilkins, 2019). This interesting 'sleight of beak' technique consists in the motion of pretending to deposit a food item in the ground with their beak (i.e., fake caching), while simultaneously sliding the food item inside their throat pouch with their tongue. The enactment of such a motion suggests that the caching individual considers that the observer might have a desired interest in the action being performed and adapts it to produce a deceptive action instead. Furthermore, the mechanics involved in 'sleight of beak' are very similar to concealment techniques used in magic. Certainly, some magicians reading this paper might find the above example particularly reminiscent of some classic sleight of hand techniques used in sponge ball effects, in which the magician will magically make a single red ball multiply inside the hands of the spectator.

The corvid family appears to also possess similar deception and perspective-taking abilities exhibited by apes (Clayton et al., 2007; Dally et al., 2006; Emery & Clayton, 2004b, 2004a). This is particularly interesting to contemplate as corvids have different social structures

than apes. Indeed, most corvids only utilise social cognition abilities within their monogamous pair bond (Emery et al., 2007), thus reducing the need for social competition. Rooks *(Corvus frugilegus)*, however, live in fission-fusion societies creating large groups during breeding season and then separating into dyads once their young become independent (Roselaar, 1994). This kind of social complexity, while different to ape social life, could account for the emergence of similar mental processes in these disparate lineages (Emery et al., 2007). Moreover, the necessity to protect caches from pilfering social competitors suggests that the Machiavellian intelligence hypothesis could also explain the evolution of complex social cognitive abilities in these large-brained birds.

Moving beyond vertebrates, noteworthy deception capabilities have also been reported amongst invertebrates – namely a group of large-brained molluscs, the cephalopods, which include octopus, cuttlefish, and squid. This family of molluscs have received particular attention from comparative psychologists as some members possess a variety of complex cognitive abilities once thought to be unique to large-brained vertebrates. For instance, common cuttlefish (*Sepia officinalis*) parallel the self-control abilities of corvids and great apes by overcoming instant gratification in favour of a delayed but more preferred food item for up to several minutes (Beran, 2002; Hillemann et al., 2014; Rosati et al., 2007; Schnell, Boeckle, et al., 2021; Wascher et al., 2020). Moreover, this species can optimise their foraging behaviour using episodic-like memory. Specifically, they can discriminately search for prey with reference to what they had previously eaten, where they had sourced their last meal and how much time had elapsed since they had last eaten (Jozet-Alves et al., 2013). This ability to recall specific past events is also evident in aged cuttlefish (i.e., cuttlefish approaching senescence), thus suggesting that contrary to humans and other primates (Gaesser et al., 2011; Nagahara et al., 2010), this type of memory in cuttlefish is preserved with age (Schnell, Clayton, et al., 2021). Another recent study has demonstrated that cuttlefish can adjust their foraging behaviour in response to proximate-future expectations. Specifically, cuttlefish can rapidly learn and remember patterns of food availability to prioritise their meals, for example by eating less crab for lunch when they expect shrimp will be available for dinner (Billard et al., 2020). This flexible foraging behaviour requires the integration of temporal information because the decision-making processes involved are influenced by both past experiences and proximate-future forecasting. However, further research is required to determine whether this type of flexible foraging in cuttlefish is also governed by the ability to plan for the future in a novel context.

Alongside their impressive cognitive capacities, these large-brained molluscs are renowned for changing their entire body appearance within milliseconds, including the pattern and texture of their skin as well as the shape of their body (Hanlon, 2007). The dynamic ability to change their appearance allows cephalopods to use deceptive resemblance to mimic inanimate objects to deceive potential predators. For example, when predators are nearby, some species of cephalopods masquerade as a rock or moving algae (Panetta et al., 2017). Cephalopods also use deceptive resemblance to deceive conspecifics, particularly during mating. Specifically, various species of cuttlefish and squid change their appearance both in colour and posture to mimic members of the opposite sex (Brown et al., 2012; DeMartini et al., 2013; Hanlon et al., 2005). Intriguingly, some species can produce deceptive signals bilaterally across one side of their body for a target audience. For example, male mourning cuttlefish *(Sepia plangon)* can display a courtship display towards a female on one side of their body and display female patterning on the other side of their body towards a rival male, in an attempt to deter the rival from interfering with his courtship behaviour (Brown et al., 2012). Although sexual mimicry in cephalopods has been described as a form of tactical deception (Brown et al., 2012), it is important to note that further research will be required to establish whether this form of deception in cephalopods is governed by complex cognitive abilities such as perspective-taking (i.e. Theory of Mind).

While magicians do not possess the ability to transform their appearance or to emit signals from their body in a similar manner to cephalopods, conjurors often transform their magic routines and narratives in reference to the behaviour elicited by the audience. The reaction of the audience when observing a magic routine will always depend on the individuals observing. As such, a good magician should not expect that a one-size-fits-all routine will make everyone react positively. A more dominant spectator might not see the funny side of being the public target of a magic effect in which the magician "fools" him. Rather, the dominant audience member

might relish at the magician making him look like he is the one that made the effect possible. Thus, a sophisticated magician will, in an effort not to demean some audience members, survey the audience and balance the individual's personality with the deception being enacted to create an illusion that amazes the audience instead of demeaning it. Could cephalopods, similarly to magicians, be taking the perspective of their audience into account when performing their shapeshifting marvels?

Given that apes, corvids, and possibly cephalopods naturally employ tactics of misdirection, which are similar to the tactics used in magic effects, it is possible that these species are exploiting similar cognitive constraints like the ones exploited by magicians. Consequently, these groups of animals are a suitable starting point to apply magic-centred frameworks to investigate the animal mind. Moreover, the use of a magical framework on such taxonomically diverse species would not only highlight the nature of such constraints, but also provide insight into the convergence of deceptive tactics in the animal kingdom and to what extent they parallel the tactics employed by magicians.

The social aspect of magic

Although methodologies often used in tactical deception are also used in magic, magic and any form of deception differ on the intentionality of the perpetrator eliciting the behaviour. Indeed, while in deception the perpetrator typically has an egocentric reasoning behind the committed behaviour, often disregarding or wilfully ignoring the damage that manipulating their counterpart might provoke. In magic, the perpetrators' principal purpose is to elicit a particular pleasurable reaction from the spectator. Therefore, while methodologically similar, magic and deception differ in their goal, in which one aims to entertain their conspecifics and the other one aims to deceive them. Certainly, the capacity to participate in deceptive behaviour as a form of entertainment is a complex notion because to partake in such an interaction, the spectator must forego the negative qualities or outcomes resulting from that experience. Therefore, making the ability of the spectator to infer the benign mental state of the magician an imperative quality of the magician–spectator relationship. Given that an inability to do so would result in the encoding of the behaviour observed as malicious intent (i.e., the magician's deception ought to be encoded as benign for the enjoyment of deception to occur). Such an ability is synonymous with sophisticated Theory of Mind as it is dependent on attributing the desire to deceive or to entertain by the spectator to the perpetrator of the act (i.e., the magician). It is thus probable that the emergence of deception tactics and the development of a sophisticated mental state attribution on early hominids was followed by the emergence of social dynamics that allowed humans to enjoy deception as a form of entertainment.

Magic as Cooperation

Social exchange, an interaction between two or more participants in which they will exchange resources (be that actions or materials) in an agreement that benefits all parties involved (Cosmides, 1989), is an intrinsic behaviour of *Homo sapiens*. Without the ability to engage in social exchange, the economic development or advancement of any society would be unlikely. Without exchange behaviour, organisational living is unlikely as there would be no tracking of goods given to the individuals of the society *vs* the goods received by them. Even magic is a sophisticated form of social exchange, in which the magician elicits wonder and surprise in exchange for other rewards (such as monetary). Indeed, the ability to partake in social exchange with others is a large intrinsic part of our social ecology, and a possible point of distinction between humans and other primates. While examples of social exchange behaviour in non-human animals are simultaneously rare and controversial (for a discussion see Carter, 2014; Clutton-Brock, 2009; Hammerstein, 2003; Hauser et al., 2009; Taborsky, 2013), cooperation between conspecifics has been observed in several species (Dugatkin, 1997). The hunting behaviour of chimpanzees, for example, has often been described as multifaceted in its collaborative effort, with different roles for each of the participants (Boesch & Boesch, 1989). However the cooperative efforts of non-human animals, while present, might not contain the same richness as human collaboration (Melis & Semmann, 2010).

Reciprocal altruism denotes the behavioural interaction between individuals whose help is restricted only to those that will aide them in response (Trivers, 1971). This has often been conjectured to be an evolutionary step towards cooperation between conspecifics (Packer, 1977). There is both observational and experimental evidence of such behaviours in non-human animals, how-

ever, the degree to which non-human animals can interact in reciprocity is still unclear (Taborsky, 2013). Indeed, in non-human primates, evidence is often criticised, as this type of selective helping can be explained by kin selection (Clutton-Brock, 2009). However, such behaviour is also present between non-kin (see Schino and Aureli (2010), and Schweinfurth and Call (2019)). While there is evidence of reciprocal altruism across different species and taxa from vampire bats (Carter & Wilkinson, 2013) and rats (Rutte & Taborsky, 2007) to finches (Larose & Dubois, 2011); chimpanzees have received the most attention when investigating reciprocity in non-human animals. This is understandable as the close link with humans can offer insight into the social and evolutionary pressures that led to cooperation in humans. Specifically, our closest relatives have often been observed, both in the wild and in captivity, engaging in reciprocal exchange of social grooming (see Schino and Aureli (2008)), and food (Jaeggi & Gurven, 2013). Moreover, chimpanzees have also been observed reciprocating across different behaviours such as exchanging food for grooming or sex (de Waal, 1997; Mitani, 2006). There is also evidence of reciprocity and prosocial behaviours occurring in monkeys such as Capuchins *(Cebus apella)* (de Waal, 2000). As such, it appears that such an intrinsic part of human socioecology precedes, to some degree, our common ancestor with chimpanzees, and raises the possibility of reciprocal interactions between conspecifics being an ever-present behaviour during a large part of primate evolution.

Exchange behaviour and cooperation has also been observed in corvids. For example, rooks *(Corvus frugilegus)* develop alliances with conspecifics (Emery et al., 2007) and have been shown to cooperate with them in problem solving tasks (Seed et al., 2008). Ravens (*Corvus corax)* exchange preening behaviours to strengthen bonds with social partners (Fraser & Bugnyar, 2010). Interestingly, evidence suggests that these large-brained birds do not necessarily engage in this behaviour solely to exchange a behaviour for another (i.e. tit for tat), but that they might be considering the utility of the reciprocated support before exchanging it (Fraser & Bugnyar, 2012).

Magic as Play

While cooperative behaviour might be present in apes, corvids, and other species, it is clear the spectator-magician relationship denotes higher socio-cognitive abilities. Certainly, the ability to understand the difference between benign and malicious deception in reference to the mental state of the perpetrator is an imperative aspect of the magician-spectator relationship that, in absence, would have made the evolution of magic improbable if not impossible. It is perhaps this fundamental ability which diverges the evolution of deception from the evolution of magic. The former being independent from such a differentiation would have carried on evolving into the behavioural repertoire of deceptive techniques which we currently see today (all of which are in turn constantly adapting and evolving into new forms of con artistry and deceit).

While there is investigation in ape and corvid's active engagement in deceitful activities, little is known about how both species react to being deceived and the cognitive processes underlying such an experience. Corvids and apes might possess the ability to infer, to a certain extent, the mental states of conspecifics. However, whether these can disassociate the negative qualities commonly attached to deceptive behaviour in reference to other's intentions is yet to be tested. As such, the question as to whether cognitively advanced animals can voluntarily partake in playful deception may pose an interesting and challenging question for future researchers.

The question of whether non-human animal's possess the ability to partake in deception as a form of play still needs to be investigated. Nevertheless, there are many accounts of behaviours displayed which suggest that non-human animals might have the capacity to engage in a wide variety of playful activities (Power, 1999). Play behaviour in non-humans has often been defined as unprompted or spontaneous self-centred actions that ensue, exclusively, in the absence of stress (Bateson & Martin, 2013). Animals can engage in three different types of play according to the direction, nature or quality of the interaction (Emery & Clayton, 2015): Locomotor play, which, as the name might suggest involves the use of motor skills as the sole active agent in play (e.g., in birds this could involve aerial acrobatics). Object play, which involves the direct manipulation of objects (other than food), which the animal might find interesting. This type of play has been suggested to be a precursor to tool use (Kenward et al., 2011) and has been linked to advanced physical cognition and problem solving (Auersperg et al.,

2015). Goodall reported data on Gombe chimpanzees self-tickling with sticks and playing catch with stones (Goodall, 1986). Similarly ravens have been observed manipulating sticks and stones without the intention of using the structures to obtain food (Bugnyar et al., 2007). Other species of corvids have been observed repeatedly sliding down steep snow-covered inclines (i.e. ski slopes, roofs, car windscreens) either on their backs (Heinrich & Smolker, 1998) or using the lid of a plastic container (Emery & Clayton, 2015). Corvids and apes also engage in social play, which involves the interaction of two or more individuals whilst playing. For example, ravens play chase in flight, play tug of war with sticks, and engage in mutual bill biting whilst grasping each other's claws (Emery & Clayton, 2015; Heinrich & Smolker, 1998). Similarly, chimpanzees have also been observed playing tug of war, play chasing each other, and wrestling (Lewis, 2005; Mendoza-Granados & Sommer, 1995; Smith & Pellegrini, 2004)

Play has also frequently been reported in octopuses. In the wild, various species of octopuses have been observed collecting and manipulating bivalve and conch shells as well as other objects (i.e. plastic or glass bottles) (Mather, 1994). In captivity, octopuses are eager to explore inanimate plastic objects (e.g. Lego pieces), they tow items around their aquarium and pass the items from arm to arm (Kuba et al., 2003; Kuba & Byrne, 2006). Play behaviours that transcend tactile exploration have also been reported. For example, giant Pacific octopuses (*Enteroctopus dofleini*) have been observed manipulating floating objects (i.e. plastic bottles) by squirting jets of water at the object, sending it to the far end of their tank and repeating this behaviour once the object returns by the current of the incoming aquarium water (Mather & Anderson, 1999).

All factors of play described could be hypothesised to be vital features for the evolution of magic as a craft and a form of entertainment. The social exchange between magician and spectator seems to be a key component of magic as a form of social play. Furthermore, as object play is linked with learning about object properties and their manipulation (Auersperg et al., 2015), it is possible that such a drive could have in hominins developed into a more sophisticated understanding of object manipulation which, in turn, could have evolved into magic-like methodologies such as sleight of hand. Consider again the example of the magician performing the flamboyant way of cutting the cards to distract the audience member: such methodology can only be created with extensive knowledge and interaction with the object being manipulated.

Conclusions and future directions

Abilities analogous to the misdirection techniques used by magicians appear to be present in species that possess complex cognitive abilities such as apes, corvids, and potentially cephalopods. By considering possible examples in these animal groups, we suggest that some non-human animals may interact with conspecifics in a manner that is analogous to some of the methodologies used by magicians to mislead others. The clear similarities between the strategies used by animals and magic effects suggest that this craft as we know it might have evolved in humans as the successor of the amalgamation of complex cognition and deceptive aptitudes. The experience of wonder and amazement that characterises the human experience of magic appears to be the main differentiator between the behaviour elicited by the non-human species presented here, and the behaviour elicited between magicians and their audiences. However, while the phenomenology of magic is characteristic of the experience, its deep-rooted links into consciousness mean that investigation with non-human animals might never be able to fully apport conclusive evidence of whether non-human animals experience magic like humans. In the absence of agreed behavioural markers of consciousness, it is difficult to corroborate conscious experience in animals. Nevertheless, research shows that animals possess complex cognitive capacities, show analogous forms of misdirection, and might also be vulnerable to similar roadblocks in cognition. These lines of evidence suggest that, at some level, the animal mind might also be capable of conscious experience when executing certain cognitive abilities (i.e., remembering, planning, deceiving). Investigating diverse taxa to test whether magic effects elicit comparable responses to that of humans might be a good starting point to investigate this line of enquiry. However, researchers must take caution when doing so. As one should not merely assume that just because an effect will exploit a mechanism in humans, the same effect will exploit the same mechanism in a non-human animal. Additionally, even if the effect were to successfully "fool" the non-human audience, the effect alone might

not offer conclusive evidence of it exploiting a similar mechanism. Nevertheless, given the discussion of this review, demonstrating that some non-human animals are effectively using analogous mechanisms to fool others, one could assume that they might already possess the necessary pre-requisite factors to get fooled: thus, prompting an inquiry into "how" not just "if".

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Supporting the psychological health of our students: An arts-based community magic workshop for adapting to university life

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ABSTRACT: The arts have long been intertwined with wellbeing and empirical attention is shifting back toward the wellbeing value of the arts. One art that has been applied in educational contexts but received limited empirical attention is that of achieving the impossible, namely, the art of performing magic. While research is young, reviews on the wellbeing-value of magic have revealed theoretical frameworks suggesting its potential to enhance self-processes and social aspects. These aspects are especially important for university students to have a psychologically healthy transition to university life because it involves integrating one's adult identity with the self, which can challenge one's self-esteem. Thus, the present study investigated how community magic workshops affect self-esteem, wellbeing, closeness, and sense of belonging for first-year university students in London. Students were allocated to either magic workshops where they learned magic tricks or mindfulness workshops during their first university term. Measures were taken at baseline, post-intervention, and a one-month follow-up. Both groups improved on all measures but students in magic workshops perceived greater benefits than the mindfulness group. Results provide preliminary evidence for using magic-based workshops as an appealing, preventative intervention that enhances the college experience for first-year students.

Throughout history, the arts have been a powerful, precious, and prevalent part of society. Not only do we see this in music, museums, and movies, but also in the artistic design of cities, landscapes, and everyday offices. Furthermore, the value of the arts is evident from their impact on scientific success (Root-Bernstein et al., 2008) as well as their impact on the economy, health, society, and education (Mowlah et al., 2014). The arts and wellbeing have long been intertwined, with scientific interest in their link growing during the 18th and 19th centuries, but as scientific advances accelerated emphasis on biomedical models began to outpace other aspects of care, especially the wellbeing value of the arts (Fancourt & Finn, 2019, Chapter 1)

However, with the advent of the biopsychosocial model of health in the past century (Engel, 1977), attention shifted back toward the wellbeing-value of arts, with scientific interest following. This wellbeing-value of the arts has been shown across all three levels of the model: biological, psychological, and social. For example, psychological benefits include reducing stress (Backos & Pagon, 1999; Dokter, 1998, p. 460; Webb, 1991), regulating emotions (Hillman, 1960, p. 340; Juslin & Sloboda, 2011, p. 1389), and enhancing self-esteem (Franklin, 1992; Hartz & Thick, 2005). Additionally, social benefits of the arts encompass increased social support (Cohen et al., 2006; Crawford et al., 2013; Murrock & Madigan, 2008) and fostering intergroup social cohesion (Lee, 2013).

This arts in health movement also includes the performance arts. The more common performance arts that have been researched include music, dance, film, singing, and theatre, which have all been used successfully in wellbeing interventions (Fancourt & Finn, 2019). Theatrical arts interventions, for instance, have been used to foster better emotional control (McDonald et al., 2020), empathy and prosocial behavior (Kou et al., 2019), and a positive self-concept in children (DeBettignies & Goldstein, 2019).

One performing art, however, that has been scientifically neglected regarding wellbeing is the art of creating the impossible: the performance art of magic. In fact, this oversight extends to whether magic qualifies as an art, which spurred Congress to pass a bill stating that magic is a rare and valuable art form (H.Res.642, 2016). Meanwhile, the scientific study of magic has increased greatly over the past decade (Kuhn et al., 2008; Kuhn, 2019; Rensink & Kuhn, 2015a, 2015b) and our current understanding is that the core of magic involves a cognitive conflict between what one perceives and what one knows to be possible (Leddington, 2016). Only recently has this empirical interest been applied to areas such as wellbeing and education (Bagienski & Kuhn, 2019, 2020; Lam et al., 2017; Wiseman & Watt, 2018).

In education, this increase of interest includes using the art of magic in primary schools to enhance social skills (Godfrey & Wiseman, 2008), increase creativity (Wiseman et al., 2021) and assist children with learning challenges (Ezell & Klein-Ezell, 2003; Spencer, 2012) . For adolescent students, it has been used to teach English as a second language (Ikhsanudin, 2017; In, 2009; Spencer & Balmer, 2020) and promote interest in STEM careers (Papalaskari et al., 2007) with the latter combining magic with theatrical arts. Within higher education, it has also been used to teach computer science (Hilas & Politis, 2014), psychology (Kuhn, 2019; Moss et al., 2016; Solomon, 1980), flexible thinking (Li, 2020; Wiseman et al., 2021) and critical thinking (Österblom et al., 2015).

Examples of the expansion to wellbeing include curiosity and its use as a distraction therapy (Labrocca & Piacentini, 2015; Peretz & Gluck, 2005; Pravder et al., 2019; Vagnoli et al., 2005), an engagement tool for physical therapy (Green et al., 2013; Harte & Spencer, 2014), and a means of enhancing self-esteem and positive self-emotions, such as pride (Danek et al., 2014; Ezell & Klein-Ezell, 2003). However, much of the theoretical basis is still speculative and these few empirical studies that do exist often lack empirical rigour. For example, studies that involve learning magic often fail to clarify whether benefits emerge from the actual performing or from factors embedded within the learning of magic (e.g., watching magic, discovering secrets, sharing secrets). Many study designs also preclude the possibility of determining whether benefits arise from magic or from simply learning a new skill (Bagienski & Kuhn, 2019, 2020). Nevertheless, the preliminary findings appear promising, most notably in suggesting that learning to perform magic may improve social skills and self-esteem (Bagienski & Kuhn, 2019).

Regarding self-esteem, prior experiments have typically involved younger participants learning and performing magic, especially in populations with low self-esteem. The majority of studies examining self-related constructs from learning magic found a positive impact (Ezell & Klein-Ezell, 2003; Fancourt & Poon, 2015; Lustig, 1994; Napora, 2021; Spencer, 2012). Two studies had inadequate statistical power, only revealing numerical increases in self-esteem scores (Kwong & Cullen, 2007; Levin, 2006) while one study had nonsignificant results (Sui & Sui, 2007). Only one experiment compared self-esteem from learning magic directly against another art, namely a drawing activity (Wiseman et al., 2021). Researchers found post-intervention scores to be lower for magic than for drawing, which is difficult to explain without baseline measures but may simply be confounded by the beneficial aspects of the drawing activity. The relationship to self-esteem exists amongst professional magicians, with self-esteem being correlated with self-efficacy, ego-resiliency, and optimism (Napora, 2021).Taken altogether, magic tricks show promise, yet some results are mixed, thus requiring high quality experiments to clarify their impact on self-esteem.

Part of the theoretical rationale for magic enhancing self-esteem is that magic increases engagement in interventions (Bagienski & Kuhn, 2019) via the intense curiosity it evokes (Leddington, 2016). Attempts to enhance self-esteem through magic also typically involve the notion of developing an impressive skill that others cannot perform (Frith & Walker, 1983), which speaks to two common theoretical models for the development of self-esteem. First is the model put forth by James (1892)

which suggests that self-esteem arises when one's perceived success in valued domains meets the expectation of one's self in that domain. Learning magic may fit these criteria, firstly, because magical content is valued by both children and adults, as evidenced by experiments showing that tricks presented with a magical causation are more interesting to explore (Subbotsky, 2010). Furthermore, many are driven to figure out how a trick works, which may suggest that learning the secret is valued, and this aligns with research on how people place greater value on things (e.g. secret knowledge) that are scarce (Cialdini, 2007). Secondly, the perceived success could be ensured by 1) choosing simple, effective magic tricks, and 2) performing them for naïve spectators to gain social proof of the success. People also tend to set aspirations and expectations of themselves in the realm of possibility, and hence their expectations of achieving the 'impossible' would be low for magic. Thus, at a certain imaginary level, learning to perform the impossible would necessarily *exceed* one's expectations. At a more realistic level, this sense of performing the impossible becomes somewhat 'real' because the social reactions to magic tricks often imply that the impossible did indeed become possible. Furthermore, since magic evokes curiosity (Bagienski & Kuhn, 2019; Leddington, 2016), these successes may create an especially salient autobiographical memory that enters one's personal narrative. Since autobiographical memory is pivotal for developing self-continuity (Robyn & Haden, 2003), this salient experience of learning magic could be particularly memorable and useful in forming one's identify via favourable self-evaluations.

The social reactions to magic would also enhance self-esteem within Cooley's (1902, p. 122) 'looking-glass' model of self-esteem, since Cooley suggests that the self is created from opinions of significant others who act as a social mirror. This idea of a social mirror is also useful in explaining why better social skills emerge in magic studies only when learning to perform magic, rather than watching magic or discovering its secrets (Bagienski & Kuhn, 2019). One rationale is that reactions to magic mimic the interested, enthusiastic, active-constructive responses that act as social validation and form the basis of positive relationships (Bagienski & Kuhn, 2019; Gable et al., 2004, 2006). Another theory is based on magic being the only art that deliberately uses speech and social cues for misdirection (Scott et al., 2018) and is thus a natural fit for improving social skills. Cooley's model has been further expanded to suggest that 'significant others' can vary throughout life, such as the more judgemental 'imaginary audience' during adolescence (Elkind, 1967) and the 'generalized other' for older ages (Harter, 2006; Mead, 1934), which may suggest that learning magic to enhance self-esteem is better suited for adults. This more general approval from the public peer domain is also more critical to self-esteem (Harter, 1990, 2006) than approval from close friends and loved ones who offer more stable, unconditional approval of one's self worth, whereas approval in the public domain is more fragile and must be earned. For this same reason, self-esteem interventions may be most fruitful in contexts where people do not know each other well.

One such context where increasing (and maintaining) self-esteem would be desirable is the period of emerging adulthood. Emerging adulthood is characterized by a period of exploration in domains relevant to adulthood such as one's career, relationships, and political, moral, or religious beliefs due to uncertainty, doubt and instability in these areas (Erikson, 1968; Nelson & Barry, 2005). As such, it is also one of highest risk periods for the onset of depression (Arnett, 2000; Nelson & Barry, 2005), especially for those making the transition to college, since it can be exacerbated by moving away from home to a more challenging academic environment and by factors like the scattering of friends, separation from family, doubts about competence, and a heightened awareness of the increasing urgency to make adult decisions (Nelson & Barry, 2005; Shulman et al., 2005).

The main developmental task at this stage, according to theorists, is identity achievement. This is achieved after adequately exploring temporary roles and making commitments in adult domains, particularly in regards to one's vocation (Erikson, 1968; Schwartz, 2001), that integrate into a coherent and meaningful identity. Thus, Erikson (1968) suggested an exploration and commitment model that was later expanded by Marcia (1980) clarifying four identity statuses based on combinations of high or low levels of exploration and commitment. At the end of adolescence nearly 50% of teenagers are estimated to be in a period of low exploration (Cote, 1996) and thus interventions for first-year college students should encourage exploratory behaviour. Drawing upon

broaden-and-build theory (Fredrickson, 2004), such exploratory behaviours could be encouraged through interventions that include positive emotions like curiosity, such as playful workshops that include magic performances. Playful magic lessons may also help facilitate the exploration and integration of identities by giving students a new, previously undefined role of 'magician' where they can comfortably explore and integrate conflicts in their possible future selves; another key task for identity achievement (Markus & Nurius, 1986).

A previous study has looked at self-esteem during the first college term. Researchers found that the participants whose self-esteem increased (or maintained a high level) were those who gained social support at college, while those who had failed to gain social support and make new social connections decreased in self-esteem (Harter, 1990, p. 166). Thus, social support is very important and as noted earlier, prior research highlights that learning to perform magic may have social benefits (Bagienski & Kuhn, 2019). Another benefit of utilizing magic is that it implies a form of entertainment instead of a therapy or mental health service, which means magic can be an appealing preventative measure for all students, regardless of whether they need psychological help.

In the current study, we set out to examine whether a novel magic-themed community workshop would enhance the wellbeing of first-year students during their first term at the university. Specifically, we focused on self-esteem and social aspects of wellbeing since prior work with magic has shown some promise in these areas. To improve and build upon prior work, we utilized a comparable control group that also practiced an activity (i.e. mindfulness). The social aspects we were interested in were how close students felt to each other and their sense of community within the psychology department. We hypothesized both to be greater for the magic group due to the more interactive performance nature, especially when social components of mindfulness training are minimized (i.e. no loving-kindness meditations). Since mindfulness can heighten an awareness of both positive and negative emotions through emotional regulation (Hill & Updegraff, 2012), we also hypothesized any self-esteem increases to be smaller in magnitude compared to the magic group. For this reason, we also expected magic to perform better on wellbeing measures of depression, anxiety and stress, especially when minimizing social components of the mindfulness, due to the strong links between social relationships and wellbeing (Lyubomirsky et al., 2005). Finally, we hypothesized that self-reported perceived measures of closeness, community belonging, self-esteem and wellbeing would follow identical patterns of magic outperforming the mindfulness workshops.

Materials and Methods

All measures, conditions, and data exclusions are reported below and in the results section. Study protocols were approved by Goldsmiths University ethics committee.

Participants

Participants were first-year undergraduate psychology students at a university in United Kingdom. We aimed for the largest sample size feasible for the first-year psychology cohort, anticipating that attrition would restrict our sample size. This first-year cohort consisted of 243 students. Of these, 133 students completed the baseline questionnaires during the first workshop and 85 completed all three measures. As expected from our university's typical demographic (Goldsmiths University of London, 2018), the sample was heavily skewed toward females (69 female vs 16 male). However, as argued by Fivush and Buckner (2003), gender differences for self-processes are less relevant during this period because college students are surrounded by similar others, of similar ages, with similar goals. Thus, the salient focus on things like academic achievement, concerns over career choice, or professional aspirations tend to overshadow gender differences, since these domains are relevant to both males and females. Chi-square tests confirmed that proportions of males and females were equally distributed across treatment groups, $\chi 2$ (2, N = 85) = .72, p = .422. In testing whether ages of participants who completed the workshops were equal, the homogeneity of variance assumption was not met, so independent sample t-tests assumed unequal variances and confirmed that ages did not differ significantly between groups, t(69.2) = 1.16, p = .242.

The students' perceived effects of workshops were also measured after the intervention and during the follow-up. For this sample, participants were included in the analysis, even if no baseline data was available that

matched up with the participant ID (or lack of ID), provided they completed at least one workshop. Thus, the sample for the perceived effects was larger with a total of 100 students in the first post questionnaire (16 male, 67 female, and 17 other or unknown due to not providing participant ID in the survey) and 87 students in the final follow-up questionnaire (17 male, 70 female).

Procedure

Students were randomly allocated by the university's timetabling team into one of six timetabling streams. Of these six streams, three were for the magic condition, and three were for a mindfulness control condition. All magic streams were given the same series of three workshops, and likewise for mindfulness streams. Workshops took place during the 9th, 11th and 13th weeks of the autumn term and lasted 1.5 to two hours each. For each week, the same mindfulness or magic workshop was delivered twice on the Tuesday of the week and once more on Friday for different groups of students. Each magic workshop ran simultaneously to a mindfulness workshop scheduled in parallel sessions, in different classrooms (See Figure 1).

To disseminate information about the workshops, all students had a module entitled 'Wellbeing Workshops' placed in their online timetable and were made aware of it during their freshman welcome week, via emails from the first-year coordinator, and reminders at tutorial sessions. By completing measurements at all three timepoints, students could receive 15 research credits that would contribute to their grade for their research methods module. All surveys were delivered in Qualtrics software that students completed on their personal phones, tablets, or laptops. Participation was optional since students could alternatively decide to participate in other studies.

The overall structure of both workshops typically began with a 'check-in' to discuss workshop content or their experience of applying it, followed by exercises to help deliver content, discussions of the experience, and ended with a recap of the main take-aways. amplify the effectiveness, 'homework' challenges were also given in both workshops that students could do outside of workshops. More specific details of the content and exercises for each workshop are outlined below.

Mindfulness workshops

Mindfulness workshops were chosen as an active control group to account for potential confounds from learning a new skill as well as ethical considerations. Since we were interested in social and communal aspects of magic, these were minimized for mindfulness workshops by intentionally avoiding mindfulness activities, such as loving-kindness meditations.

The first of the three workshops focused on giving students a definition of mindfulness, explaining awareness, presence and nonjudgement, and encouraged students to pay attention to bodily sensations. Exercises included squeezing one's fist with and without paying attention to one's breath, and a 10-minute guided body scan meditation. As home practice, students were encouraged to pay mindful attention to an everyday task and use the free Insight Timer app for guided meditations.

The second workshop focused on the link between bodily sensations and emotions, as well as how this is relevant in everyday life. A personal story was given by the facilitator on how noticing one's emotion helped him to react appropriately to a stressful situation and exercises included a 15-minute body scan meditation, a 10-minute mindfulness of breath meditation, and a mindful movement exercise.

The third workshop focused on equanimity, the negative impact that lacking mindful awareness can have when responding to unpleasant events, and the positive impact it can have on enjoying life more. Exercises included a mindful movement exercise, a 15-minute body scan meditation, and a mindful eating exercise with cake or chocolates.

Magic workshops

Magic workshops were delivered by Abracademy, a company that blends learning design and facilitation techniques with the teaching of magic tricks (*Abracademy*, n.d.). All magic tricks that were taught were chosen to be a beginner's difficulty to ensure students could successfully learn the trick in a short period of time.

The first magic workshop focused on the concept of belief in one's self, in others, and in making the 'impossible' become possible. After a short magic performance, there was a brief check-in for introductions, followed by asking students about the values they would like to have during the workshops. To target self-esteem, a second

Figure 1. Summary of workshop protocols and measures. All magic and mindfulness sessions and measures occurred simultaneously in parallel sessions. The follow-up sessions were e-mailed to participants.

magic performance about the magician believing in himself was then performed, which transitioned into a third performance where a student volunteer used 'magical powers' to create a glowing orb of light that the magician could vanish, re-appear, and toss around. This glowing orb magic trick (Mayfarth, 2017) was taught to all students, who practiced handling the light with both the whole group and in pairs. After mastering this trick, students were taught how belief can be conveyed through body language and a magic pen trick was taught to practice these body language skills. The pen trick involved piercing a piece of paper currency and magically restoring the hole in the currency (Premium Magic, n.d.). This body language skills were intended to foster community and closeness through developing communication skills The homework challenge given to students was to watch themselves perform the trick in a mirror, video, or method of their choosing and post a video of their solo performance in a WhatsApp group. They were also given a customized website with resources to review what they learned.

To further target community belonging and closeness, the second workshop focused on connecting with one's audience and other people through story and relatable content. It started with a magic performance, which was used as a springboard for discussion on ways the magician may have made his performance more believable. The discussion was facilitated to include body language as well as the use of relatable stories to connect with the audience. The importance of improvisation was also introduced, and students engaged in an improv exercise in small groups. Next, half of the class learned one trick where two ropes turned into one long rope (variation of *Professor's Nightmare*, n.d.)and the remaining half learned a a trick where a pen vanishes in the performers hand (Cornelius, n.d.). After practicing, each student then performed for a student who did not learn the same trick. To conclude, the students formed groups based on an emotion they wanted to convey through their magic. After deciding and practicing their presentation in groups, each group then performed in front of the entire class. The homework challenge was to perform for three people, optionally record it, and request feedback on what went well and how to improve the performance.

The final magic workshop focused on helping students discover their 'magical' self by exploring their strengths in order to target overall wellbeing and self-esteem. The first magic performance was used as an example of how performing magic was a strength of the performer. Other exercises included sharing a time at their best in pairs before discussing strengths they saw in their partner's story, and an interactive magic trick where students wrote these strengths on cards. After writing them down, students tore them in half, shuffled them, and during the climax of the trick they alternated chants of 'I love myself!' with 'Not so much' (for comedic effect) as they tossed away cards in the air until two torn halves remained, which "coincidentally" matched perfectly (Aragon, n.d.). All students then learned one final magic trick where a matchbox mysteriously moved on its own (Ginn & Bergeron, 1977) and the workshop culminated in an activity where students wrote strengths they saw in others on sticky notes, which were stuck on the back of the corresponding person as music played.

Measures

The variables of interest were students' self-esteem, psychological closeness, belongingness, and general wellbeing. The scales used for pre- and post-measures were administered immediately before the first workshop began, immediately after the final workshop, and at the 1-month follow up. The perceived effects were asked immediately after the final workshop and once more at a 1-month follow up. All items were within the same questionnaire, created with Qualtrics web software.

Self-esteem

Self-esteem was measured using the Self-Perception Profile for College Students (Neeman & Harter, 1986). Seven of the 13 domains were chosen based on a hypothesized relevance to magic. The chosen domains and reliabilities as assessed by Cronbach's alpha during baseline were as follows: Creativity = 0.84, Intellectual Ability = 0.74, Scholastic Competence = 0.70, Social Acceptance = 0.79, Close Friendships = 0.75, Finding Humor in One's Life = 0.82, and Global Self-worth = 0.88. Each item presents descriptions of two types of students on opposite ends of a spectrum and respondents are asked to to select "which student is most like *you*" and rate how true it is for the respondent. Each item score ranges from one to four, with higher scores indicating

higher self-esteem within that domain. All domains contain four items each except for Global Self-worth, which contains six.

The perceived effect on Self-esteem was measured quantitatively by asking participants "How do you think the workshops affected the way you feel about yourself (i.e. self-esteem)?" on a 7 point scale from "Much worse about myself" to "Much better about myself". This was followed with the qualitative, open ended question: "If you feel the workshops affected the way you feel about yourself (i.e. self-esteem), please describe how and why?"

Closeness

Closeness was measured via the Inclusion of Other in Self (IOS) scale (Aron et al., 1992), which contains a single item with 7 paired circles depicting different degrees of overlap between two overlapping circles labelled 'Self' and 'Other'. The item instructed participants to 'Please select the picture that best describes your current relationship with other [University name] psychology students.' The original development demonstrated good reliability (alternate form reliability, α = .87 to .95; and test-retest reliability of .85 [Aron et al., 1992]).

The perceived effect of closeness was measured quantitatively by asking participants 'To what extent do you feel the workshops have affected how close you feel to other [University name] psychology students?' on a 7-point scale from 'Much less close' to 'Much closer'. This was followed by the qualitative, open ended question: 'If you feel the workshops affected the closeness of your friendships and relationships with other students, please describe how and why?'

Community Belonging

Community belonging was measured via the perceived cohesion scale (Bollen & Hoyle, 1990, p. 485), with the term "[University name]'s psychology" as the referent community. Reliability as assessed by Cronbach alpha during baseline was .93.

The perceived effect of belonging was measured by asking participants 'How do you feel the workshops affected your sense of belonging in [University name] psychology?' on a 7-point scale from 'Belong much less' to 'Belong much more'. This was followed with the qualitative, open ended question: 'If you feel the workshops affected your sense of belonging, please describe how and why?'

Wellbeing

Other aspects of wellbeing were measured by first using a general life happiness measure via the question 'Overall, how happy are you with your life as a whole these days?' on a 7-point scale. The second measure of wellbeing was Henry and Crawford's (2005) short form of the Depression, Anxiety, and Stress Scale (DASS-21). Reliability as assessed by Cronbach alpha during baseline for subscales was as follows: Depression = .86, Anxiety = .81, Stress = .85.

The perceived effect of wellbeing was measured by asking participants 'How do you feel the workshops affected your general sense of wellbeing at [University name]?' on a 7-point scale from 'Much lower' to 'Much

	Magic						Mindfulness (control)					
	Pre		Post		Follow Up		Pre		Post		Follow Up	
	M	SD	M	SD	M	SD	M	SD	M	SD	M	SD
Self-Perception Profile for College Students												
Scholastic Competence	2.20	0.61	2.42	0.62	2.36	0.58	2.32	0.55	2.48	0.61	2.45	0.57
Social Acceptance	2.53	0.74	2.69	0.74	2.71	0.70	2.65	0.68	2.72	0.68	2.75	0.64
Close Friendships	2.52	0.73	2.72	0.78	2.65	0.77	2.76	0.72	2.94	0.68	2.91	0.71
Intellectual Ability	2.31	0.61	2.46	0.61	2.48	0.63	2.32	0.71	2.51	0.71	2.54	0.68
Finding Humor in One's Life	3.09	0.66	3.14	0.72	3.14	0.70	3.17	0.66	3.26	0.70	3.32	0.59
Creativity	2.24	0.69	2.38	0.66	2.43	0.66	2.33	0.68	2.48	0.66	2.48	0.70
Global Self-worth	2.66	0.70	2.80	0.64	2.77	0.69	2.67	0.72	2.73	0.71	2.74	0.72
Inclusion of Other in Self Scale (closeness)	5.23	1.17	5.05	1.47	5.15	1.43	4.90	1.32	5.16	1.49	5.16	1.41
Perceived Cohesion Instrument (belonging)	2.79	1.22	3.33	1.62	3.32	1.56	3.01	1.37	3.42	1.49	3.49	1.51
Life Happiness	5.14	2.24	5.68	2.46	5.63	2.40	5.43	2.01	6.22	2.17	6.48	1.90
DASS-21												
Depression	12.30	9.68	10.61	9.94	11.21	10.93	12.30	9.36	10.60	9.05	10.24	8.80
Anxiety	14.58	10.11	12.24	9.18	11.73	10.29	14.03	9.76	13.16	8.92	11.16	9.15
Stress	16.09	9.96	14.00	9.24	14.76	10.53	17.94	9.67	16.21	10.82	15.07	10.52

Table 1. Means and standard deviations for magic and mindfulness groups at baseline, post measure, and follow up measure.

higher'. This was followed by the qualitative, open ended question: 'If you feel the workshops affected your general sense of wellbeing, please describe how and why?'

Data Analysis

To determine the effectiveness of the intervention for self-esteem, closeness, belonging and general wellbeing, thirteen 2 x 3 mixed ANOVAs with condition (magic, control) as the between subjects variable and time (baseline, post, and one month follow-up) as the within subjects variable were conducted for each scale or subscale. Last observation carried forward Intention to Treat (ITT) analysis was also used (Ranganathan et al., 2016) to ensure conservative results and take into account attrition rates.

To determine differences between groups on perceived effectiveness of the workshops on self-esteem, closeness, belonging, and wellbeing, a series of t-tests were conducted on scores at both the post measure and the one-month follow-up.

Results

A summary of the mean scores and standard deviations for the scales is presented in Table 1 and the perceived measures are presented in Table 2. The analysis for perceived effects tested the differences between the groups on self-reported, perceived effectiveness of the workshops in four domains: self-esteem, closeness with other students, belongingness at the university, and general wellbeing. The ANOVA analyses tested whether these four domains improved over the course of the workshops and whether it sustained at a one-month follow-up (See Tables 3-5).

A total of 133 students completed the baseline measures. Of these, 89 completed the post measure, and 85 completed the follow-up measure (mean age = 19.16, SD = 1.74). Of those who completed the follow-up measures, two did not complete the post measure. Thus, as per last observation carried forward ITT analysis, the most recent score was carried forward and treated as 'no change'.

Some students participated in the workshops but were missing baseline data. For these students, they were included in analyses only for perceived measures, provided they attended at least one workshop. This resulted in a total sample size of N = 100 for the perceived post measures, and N = 87 for the one-month follow-up measure.

Self-Esteem

Self-Perception Profile for College Students

There was a main effect of time, $^{*}F(1.56, 203.65) = 5.79$, $p < .01$, $\eta^2 = 0.04$, showing increased global self-esteem over the course of the interventions. There were also main effects of time showing increased self-esteem in the subscales of scholastic competence, $F(2, 262) = 13.45$, $p < .001$, $\eta^2 = 0.09$; social acceptance, $^{*}F(1.83, 239.78) = 8.20$, $p < .001$, $\eta^2 = 0.06$; close friendship, $F(2, 262) = 12.19$, $p < .001$, $\eta^2 = 0.09$; intellectual ability, $^{*}F(1.91, 249.54) = 15.58$, $p < .001$, $\eta^2 = 0.11$; finding humour in one's life, $^{*}F(1.85, 241.72) = 3.70$, $p < .05$, $\eta^2 = 0.03$; and creativity, $F(2, 262) = 10.68$, $p < .001$, $\eta^2 = .08$. There were no significant main effects of condition nor any significant interaction effects for all pre and post measures of self-esteem (See Tables 3-5).

	Magic (n = 51, 47)				Mindfulness (n = 49, 40)			
	Post		Follow Up		Post		Follow Up	
	M	SD	M	SD	M	SD	M	SD
Self-Esteem	5.61	1.23	5.06	1.05	4.71	1.06	4.55	0.96
Closeness	5.73	1.00	5.43	1.12	4.69	1.00	4.80	1.02
Community Belonging	5.47	1.16	5.09	1.06	4.65	0.93	4.60	0.71
Wellbeing	5.33	1.16	4.89	0.96	4.71	0.98	4.50	0.75

Table 2. Means and standard deviations for perceived scores of magic and mindfulness groups measured at the end of the intervention and 1-month follow-up.

[*] Greenhouse Geisner correction applied to analysis in cases where Mauchly's test of sphericity was significant for uncorrected model and are indicated by asterisks (*).

	F	df 1	df 2	p	η^2
Self-Perception Profile for College Students					
Scholastic Competence	13.45	2	262	< .001	0.09
Social Acceptance*	8.20	1.83	239.78	< .001	0.06
Close Friendships	12.19	2	262	< .001	0.09
Intellectual Ability*	15.58	1.91	249.54	< .001	0.11
Finding Humor in One's Life*	3.70	1.85	241.72	.03	0.03
Creativity	10.68	2	262	< .001	0.08
Global Self-worth*	5.79	1.56	203.65	.003	0.04
Inclusion of Other in Self Scale (closeness)*	15.85	1.85	224.47	< .001	0.11
Perceived Cohesion Instrument (belonging)*	18.66	1.74	227.48	< .001	0.13
Life Happiness*	0.45	1.86	243.26	.63	n/a
DASS-21					
Depression*	5.53	1.86	244.03	.004	0.04
Anxiety	11.7	2	262	< .001	0.08
Stress*	7.48	1.87	244.62	< .001	0.05

Table 3. Results showing within-subject main effects of time from ANOVA analyses. Asterisks indicate that Greenhouse Geiser correction was used.

Perceived Self-esteem

For the perceived effects on self-esteem during the post measure, results indicated that the magic group perceived significantly higher improvements in how they felt about themselves (due to the workshops) than the mindfulness group did, with a large effect size, $t(98) = 3.88$, $p < .001$, $d = 0.78$. For the final follow-up survey, the same trend was found with a smaller, yet still significant, medium effect size, $t(85) = 2.37$, $p < .05$, $d = 0.51$. Means for both groups were above the midpoint (i.e. value of 4) at all timepoints, which suggests that both interventions were perceived as beneficial for self-esteem (See Tables 3-5).

Closeness

Inclusion of Other in the Self

There was a main effect of time, $*F(1.85, 224.47) = 15.85$, $p < .001$, $\eta^2 = 0.11$ showing an increased sense of closeness with other psychology students over the course of the interventions. There were no significant main effects of condition nor any significant interactions (See Tables 3-5).

Perceived Closeness

For the perceived effects of closeness during the post measure, results indicated that the magic group perceived significantly higher improvements in how close they felt with other students (due to the workshops) than the mindfulness group did, with a large effect size, $t(98) = 5.14$, $p < .001$, $d = 1.0$. For the follow-up measure, the same trend was found with a smaller, yet still significant,

	F	df 1	df 2	p	η^2
Self-Perception Profile for College Students					n/a
Scholastic Competence	1.00	1	131	0.32	n/a
Social Acceptance*	0.31	1	131	0.58	n/a
Close Friendships	4.07	1	131	0.05	n/a
Intellectual Ability*	0.17	1	131	0.68	n/a
Finding Humor in One's Life*	1.39	1	131	0.24	n/a
Creativity	0.49	1	131	0.48	n/a
Global Self-worth*	0.07	1	131	0.80	n/a
Inclusion of Other in Self Scale (closeness)*	0.51	1	131	0.48	n/a
Perceived Cohesion Instrument (belonging)*	2.6	1	131	0.11	n/a
Life Happiness*	0.10	1	131	0.75	n/a
DASS-21					n/a
Depression*	0.05	1	131	0.83	n/a
Anxiety	0.00	1	131	0.97	n/a
Stress*	0.18	1	131	0.37	n/a

Table 4. Results showing between group main effects from ANOVA analyses. Asterisks indicate that Greenhouse Geiser correction was used.

	F	df 1	df 2	p	η^2
Self-Perception Profile for College Students					
Scholastic Competence	0.35	2	262	0.71	n/a
Social Acceptance*	0.83	1.83	239.78	0.43	n/a
Close Friendships	0.12	2	262	0.89	n/a
Intellectual Ability*	0.23	1.91	249.54	0.79	n/a
Finding Humor in One's Life*	0.79	1.85	241.72	0.45	n/a
Creativity	0.22	2	262	0.80	n/a
Global Self-worth*	0.69	1.56	203.65	0.47	n/a
Inclusion of Other in Self Scale (closeness)*	0.26	1.85	224.47	0.76	n/a
Perceived Cohesion Instrument (belonging)*	2.03	1.74	227.48	0.14	n/a
Life Happiness*	2.65	1.86	243.26	0.08	n/a
DASS-21					
Depression*	0.48	1.86	244.03	0.61	n/a
Anxiety	1.04	2	262	0.36	n/a
Stress*	1.40	1.87	244.62	0.25	n/a

Table 5. Results showing interaction effects of time by group from ANOVA analyses. Asterisks indicate that Greenhouse Geiser correction was used.

medium effect size, $t(85) = 2.37$, $p < .01$, $d = 0.59$. Means for both groups were above the midpoint (i.e. value of 4) at all timepoints, which suggests that both interventions were perceived as beneficial for closeness.

Belonging

Perceived Cohesion Scale

There was a significant main effect of time, $^{*}F(1.74, 227.48) = 18.66$, $p < .001$, $\eta^2 = 0.13$, showing an increased sense of belonging to the psychology community, over the course of the intervention. There were no significant main effects of condition nor any significant interactions (See Tables 3-5).

Perceived Belonging

For the perceived effects of belonging during the post measure, results indicated that the magic group perceived significantly better improvements in their sense of belonging to psychology (due to the workshops) than the mindfulness group did, with a large effect size, $t(98) = 3.90$, $p < .001$, $d = 0.78$. For the final follow-up survey, the same trend was found with a smaller, yet still significant, medium effect size, $t(85) = 2.436$, $p < .05$, $d = 0.54$. Means for both groups were above the midpoint (i.e. value of 4) at all timepoints, which suggests that both interventions were perceived as beneficial for community belonging.

General Wellbeing

WellbeingDASS-21 and life happiness

There were no significant main nor interaction effects for the life happiness measure (See Tables 3-5). There were, however, significant main effects of time in the DASS-21 indicating a decrease in depression, $^{*}F(1.86, 244.03) = 5.53$, $p < .005$, $\eta^2 = 0.04$; anxiety, $F(2, 262) = 11.70$, $p < .001$, $\eta^2 = 0.08$; and stress, $^{*}F(1.87, 244.62) = 7.48$, $p < .001$, $\eta^2 = 0.05$. There were no significant main effects of condition nor interactions for any subscales of the DASS-21.

Perceived Wellbeing

For the perceived effects of wellbeing during the post measure, results indicated that the magic group perceived significantly higher improvements in their general sense of wellbeing (due to the workshops) than the mindfulness group did, with a medium effect size, $t(98) = 2.88$, $p < .005$, $d = 0.58$. For the final follow-up survey, the same trend was found with a smaller, yet still significant, medium effect size, $t(85) = 2.10$, $p < .05$, $d = 0.45$. Means for both groups were above the midpoint (i.e. value of 4) at all timepoints, which suggests that both interventions were perceived as beneficial for general wellbeing.

Discussion

Undergraduate students during their first term of college took part in either magic or mindfulness workshops. To examine the impact of the workshops on the students' self-esteem, closeness, community belonging, and general wellbeing, measures were taken before the workshops, immediately afterwards, and at a one-month follow-up. Overall, improvements were found for both workshops in all measures across time and thus appear to be beneficial. Contrary to our hypothesis, however,

the pre- and post-measures showed no significant between group differences. On the other hand, students reported larger perceived benefits for the magic workshops, compared to mindfulness workshops. This was true for perceived effects on self-esteem, closeness, belonging, and wellbeing at both the post measure and the one-month follow up. While not measured directly, the engagement in the WhatsApp chat for the magic group was low with no shared videos, and only contained a few thank you messages from students. However, discussions during both magic and mindfulness workshops revealed that at least some students engaged with the homework challenges.

Consistent with prior research on magic and wellbeing (Bagienski & Kuhn, 2019), our results show that participants perceive learning magic as useful in enhancing self-esteem and social relationships. Prior research on undergraduate students during their first term of college suggests that self-esteem tends to either 1) remain stable overall due to an equal amount of students feeling better about themselves as there are for students who feel worse (Harter, 2012, p. 166), or 2) decrease by the end of the first term (Chung et al., 2014). Thus, the self-esteem improvements we found are unlikely an artefact of normative adjustment, and instead suggest that the interventions were indeed effective. Practical limitations include a lack of an inactive control that practiced nothing, and attrition rates may have resulted in a somewhat self-selected sample.

At first glance, the discrepancy between standardized measures at the three timepoints and the perceived effects is rather perplexing. Indeed, if both groups had improved, one might expect the mindfulness group to be more aware of the positive impact and report higher perceived effects. However, it is important to consider that by design the content of the mindfulness workshops did not focus specifically on any social or self-components, whereas these topics were much more salient in the magic workshops. For example, the final magic performance included students chanting alternating statements of "I love myself" and "Not so much" (for entertainment value), which could have affected self-esteem scores through a desire to please the facilitators. Likewise, the body language lessons and tips on connecting with the audience may have made students pay more attention to how the workshops affected their sense of belonging and closeness to other students. Thus, while both workshops improved self-esteem, community belonging, and closeness, these benefits may have been more implicit in the mindfulness group (i.e. beyond participants' awareness) and much more explicit in the magic group, to the point that the salient content overshadowed any mindful awareness of the benefits. However, this does not explain why the magic group's perceived effects on "wellbeing" was larger than the mindfulness group. An alternative explanation is that watching magic created strong curiosity and interest (see Bagienski & Kuhn, 2019; Leddington, 2016), which may have generalized to noticing a broad number of positive changes. Lending support to this idea of a more general, introspective awareness is that salient content does not account for the decreases in depression, anxiety and stress since these were not even mentioned during the magic workshops. Whether and how curiosity from magic tricks can be 'attached' to learning material is beyond the scope of this study but a worthwhile line of future research as current studies have mixed results (e.g. Lustig, 1994; Moss et al., 2016; Wiseman et al., 2020).

One speculative explanation for the positive impact would be that magic catalyses an initial willingness to engage, which makes it easier to engage participants in subsequent activities that lead to more lasting change. This initial interest may stem from how most people have very limited experience with magic, compared to other entertainment mediums like music, movies, or television. Thus, participants would have more uncertainty on what to expect and ultimately become more curious to learn about the workshops, especially since magic is stereotypically shrouded in secrets. Once participants arrive and begin learning to perform magic, Cooley's (1902) model of self-esteem arising from a "social mirror" may then play a role in enhancing self-esteem. This was anecdotally observed in workshops when students performed their tricks to an unwitting peer who was unaware of the trick's secret method. Many students expressed surprise by both the magic their partner performed and also by the fact that they successfully "fooled" their partner with their own magic performance. Thus, the social reaction to the magic trick acted as a "social mirror", which challenged their initial self-evaluation of being someone who cannot perform magic well.

In terms of self-esteem scales, the main effects of both workshops had medium to large effect sizes. The

largest effects were in intellectual self-esteem followed by scholastic, close friendships, creativity, and social-acceptance self-esteem (in order of decreasing effect size). Influences on close friendships and social-acceptance are in line with findings of social support's critical role in maintaining self-esteem during the college adjustment (Friedlander et al., 2007; Harter, 2012). The smallest effects were for global self-esteem and finding humour in one's life. The humour subscale relates to not taking oneself too seriously and since humility was not salient in either workshop, it's reasonable to have a smaller effect size. As for global self-esteem, the smaller effect size might be indicative of workshops not targeting every single area of importance to one's worth in college, such as romantic relationships or uncertainties about vocation. We attempted to minimize the confounds of practicing a skill and social benefits of the comparison group by utilizing mindfulness sessions without any loving-kindness practices. Nevertheless, mindfulness has psychological benefits as well (Chiesa & Serretti, 2009), which may have still been present in our measures and explain why no between groups effects were found. Since different elements of wellbeing also tend to be correlated, (Goodman et al., 2018; Seligman, 2018) mindfulness benefits may have very well carried over into self-esteem. Furthermore, positive interventions with healthy individuals (as is the case here) tend to have small effect sizes (White et al., 2019), albeit more sustainable, than clinical effects. As a consequence, the results from the pre- and post-scales may have been underpowered whereas our perceived measures better detected the unique impact from the magic workshop. Thus, one extension of the current study for future research would be to have a control group that practices no activity at all.

Contrary to results from established scales, the perceived effectiveness of workshops on self-esteem suggests that the magic workshops were more effective than the mindfulness workshops. As noted earlier, the discrepancy could be partly explained due to the salient content in the magic workshop or perhaps an enhanced curiosity and interest that was inspired by the magic. Furthermore, effect sizes were large on the perceived measures, which suggests that perceived measures were more sensitive to the benefits of the workshops than the pre-post comparisons for standardized scales. We suggest that the standardized measures could not detect a between-groups difference because the additional contribution from magic was small and confounded by psychological benefits of mindfulness. Thus, future studies should focus on larger samples to increase statistical power.

For social benefits, results were similar to self-esteem. The main effects from ANOVAs showed community belonging and closeness to have large effect sizes. Our attempts to minimize the social impact from mindfulness may have been thwarted by correlations in elements of wellbeing (Goodman et al., 2018; Seligman, 2018), such as an indirect effect of mindfulness on closeness and community belonging. The lack of social aspects in mindfulness was deliberate in this experiment, which may suggest that while both workshops yielded similar results, the mechanisms between the two could be very different. For the more sensitive perceived measures, closeness with other students had the largest between-group difference, supporting our hypothesis that the magic workshops would have greater social benefits.

For the wellbeing measures, the effect sizes of the ANOVAs were medium. For perceived effects, the wellbeing question had the smallest effect size, which is not surprising as the magic workshops did not specifically focus on eliminating depression, anxiety or stress. It is interesting, however, that the magic groups still perceived the wellbeing benefit, which suggests that participants were not simply giving a positive response bias due to salient content, as might be argued for the self-esteem and social benefits. This adds greater weight on the aforementioned explanation of magic generating curiosity that generalizes to a more general, introspective awareness.

Limitations of the current experiment include the fact that both groups learned something, making it difficult to discern how much change from pre- to post- to follow-up can be explained by practicing a skill. Furthermore, the content of the workshops may have unmeasured confounds that play a role. Arguably, this may be particularly the case for the magic workshops, which included music, light physical movement, storytelling exercises, and discussions on believing in yourself and in the 'impossible'. At a real-world, practical level, these confounds may not matter if they are all present in the workshop. To determine the unique contribution of magic, however, it is crucial for future experiments to

examine individual components of the workshops (e.g. simply learning a magic trick, performing magic to a naïve spectator, testing different tricks, etc.). Other limitations include the largely female sample, attrition that may have created a self-selected sample, and due to the length of the surveys, survey fatigue may have resulted in careless responding. These could be addressed by incorporating attention checks in the survey design and utilizing a control that learns no new skills. The lack of an inactive control, such as a waitlist, may also be seen as a limitation, although we consider this a strength of the study, since the active control is a conservative test of workshop effectiveness.

Emerging adulthood can be a period of heightened risk for depression and engaging in risky behaviours (Harter, 2012). As such, exploring ways to enhance the college transition experience is critical. Of particular importance is building a means of social support through the college community and maintaining healthy levels of self-esteem. Our preliminary study is the first to suggest that magic workshops may have potential in this context. One of the benefits of such interventions is that they are less prone to stigma because magic tricks are not typically associated with therapy or treatment of low self-esteem. Additionally, they can be useful preventative measures for attracting students with healthy levels self-esteem since one of the unique attributes of magic is the curiosity it inspires by creating impossible moments (Leddington, 2016). Furthermore, by learning to achieve these 'impossible' moments and performing them for others, magic would have positive implications for self-evaluations. Magic is also one of the few performance arts that can be easily applied in intimate, one-on-one social interactions, and thus provide the building blocks of a close-knit community. This sense of community may very well provide the social support needed for healthy college adjustment (Friedlander et al., 2007; Harter, 2012) and ultimately ease the transition. While mindfulness-based interventions could also be helpful for certain students, magic workshops nevertheless provide a more interactive alternative for those students who struggle to engage with passive mindfulness activities like meditation.

In conclusion, the workshops had a positive effect and considering that most studies have shown decreases or stagnant changes in self-esteem when students first adjust to college life, it is unlikely to be a mere case of normative adjustment. The perceived effects may have been more sensitive and thus able to detect between group differences, which suggest that the magic workshops were more useful for self-esteem, closeness, community belonging, and wellbeing. Although further research is needed, this preliminary study suggests there may be some advantages of magic-based interventions over other types of interventions. Additionally, experiments that separate out the magic from other confounds would be useful for furthering a theoretical understanding.

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