Effect of Monetary Reward on Manual Automatic Imitation

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Abstract

Automatic imitation is an ongoing topic of research across various domains including neuroscience, social psychology, and cognitive psychology. It is unclear how automatic the process really is, but previous studies suggested that motivation as measured with reward manipulation could discern between intentional and automatic imitation. The present study investigated the influence of reward manipulations on the automatic imitation effect. Specifically, we conducted an online study with a between-subjects design (N = 83) comparing the performance between participants with monetary incentives (reward group) and participants with no monetary incentives (no -reward group) through a stimulus-response compatibility (SRC) key-pressing task. We found an automatic imitation effect, demonstrated by faster response times for congruent trials than incongruent trials, but no effect of the reward manipulation is observed in this study. We concluded that automatic imitation was not modulated by reward suggesting that the imitation process was automatic.

Keywords: **imitation, rewards.**

Introduction

Automatic imitation

Imitation is a common behaviour in humans and animals alike and has garnered scientific interest to understand its nature. The term "imitation" refers to any circumstance in which an observer performs the same action as what they observe, including both intentional and involuntary copying (Chartrand & Bargh, 2002; Catmur, 2016). Behavioural studies postulate a connection between imitation and motor neural networks in the brain, or else ubiquitously known as motor mimicry or imitation. Automatic imitation has been investigated in various domains such as perceptuomotor processing of speech (Jarick & Jones, 2009; Adank et al., 2018), emotional processing (Mondillon et al., 2007; Butler et al., 2016), motivational stimulation (Soutschek et al., 2014), and social context (Pan & Hamilton, 2015). In these studies, an individual observing an action performed would have the tendency to involuntarily imitate the observed action, given that the visual depiction of the action and of self-motor program matches (Catmur, 2016). The central debate surrounding imitation focuses on its propensity to be "automatic", and has received considerable interest among researchers to distinguish between a controlled imitation and an automatic imitation by their underlying cognitive processes.

Automatic imitation refers to the phenomenon that motor planning of an observed action is activated independent of intentional, top-down cognitive control processes resulting in covert imitation (Brass et al., 2001; Heyes, 2011). Neuroimaging studies have pointed to areas of the brain considered as part of the mirror neuron system. In this system, a set of brain areas are activated both during observation and execution of specific actions; for example, during speaking and listening (Rizzolatti et al., 2001; Cross & Iacoboni, 2014). In behavioural experiments, automatic imitation can be elicited through the stimulus-response compatibility (SRC) experimental paradigm which is described in detail below (Brass et al., 2000).

Previous research has substantially expanded the understanding of automatic imitation of observed action in a variety of contexts, such as when primed with pro-social vs anti-social sentences (Wang & Hamilton, 2012). In Wang & Hamilton (2012), they investigated whether priming pro-social and anti-social sentences could influence imitation in a finger-tapping task; a larger automatic imitation effect was found for anti-social sentence priming than for the pro-social sentence priming. Another study compared possible vs impossible finger movements in an SRC task performed by a biomechanical hand, as well the effect of attentional weighting, i.e., when subjects were aware of both possibilities, on automatic imitation effect (Longo et al., 2008). Interestingly, automatic imitation was elicited for both possible and impossible finger movements, but the effect vanished when subjects were aware of the impossible movements. Longo and colleagues (2008), through this finding, proposed that finger movements were coded in terms of the goal, not the manner in which the action is performed. The automaticity of imitating observed action has been supported in these studies in which they demonstrated how social contexts could influence the effect of imitating congruent and incongruent hand or finger movements. Pan and Hamilton (2015) investigated automatic imitation in a rich social environment with virtual characters (VC) and balls performing compatible actions. They found an automatic imitation effect (measured by faster response times to stimuli shown) for compatible trials, and that the effect was larger for action performed by VC compared to balls. A major consideration of past evidence is about discerning an imitation which is initiated by cognitive control to an imitation which is automatic, independent of intentional and deliberate cognitive control.

Research in automatic imitation is imperative to understanding the concentration required to suppress the urge to imitate upon observing someone else act. Scerrati et al. (2017) reported the role of spatial attention in the coding of spatial position of a stimulus in a Simon's task, where a right/left-located visual stimuli of a square with a frame of varying colours were presented to participants. They were asked to discriminate against either the colour of a square or the colour of a square's frame using a left or right index finger keypress. This resulted in a Simon effect, in which the response times were faster when the required response is spatially congruent with the stimulus location, showing that performance is facilitated almost automatically for spatially congruent stimulus-response pairings. It is necessary to clarify that the term 'automaticity' is defined in terms of the level of processing of which very little cognitive control occurs, and in the context of imitation task, a response follows automatically once a compatible and task-relevant stimulus are instantiated (Moors & de Houwer, 2006).

The conundrum regarding higher-level cognitive processing in the context of action perception and motor planning is a difficult one, as the role of attention control remains ambiguous and without a strong consensus in the present literature. Heyes and Catmur (2021) proposed that mirror neurons are involved in perceiving actions with low-level processing (e.g., precision of hand grip), but not those requiring higher-level processes (e.g., inferring actions of others). Indeed, the most prominent discussions of automaticity describe three main characteristics of this concept: effortless, stimulus driven, and operates outside awareness (Laberge & Samuels, 1974; Schneider & Shiffrin, 1977).

Motivational account and relationship with automatic imitation

Given that the underlying process governing automatic imitation is still unclear and under debate, studying reward might explain if automatic imitation is truly automatic or if it can be manipulated by an intentional decision process. Motivation, which is driven by social and psychological factors, can be modelled in many ways but is categorized into two famously known archetypes: intrinsic (autonomy and purpose) and extrinsic motivations (reward and punishment; Reiss, 2012). The extrinsic aspect was of our interest as it was presumably easier to manipulate through experimental design. Additionally, Soutschek et al. (2014) demonstrated the association between monetary reward and conflict processing in a Stroop task, requiring participants to respond to the colour of a word whilst ignoring its meaning. The main finding of their experiment was that the response time did not differ between the congruent and incongruent trials when there were monetary incentives. The performance-dependent paradigm of the experiment could enhance focus of attention and perhaps cognitive control, which would subsequently facilitate conflict resolution for the incongruent trials. In the present work, we were interested in the extrinsic factor of motivation (monetary incentives) in controlling reward sensitivity, and its effects on a goal-directed behaviour. Specifically, we tested the influence of monetary incentive on automatic imitation effect, examining whether the prospect of monetary reward could inhibit or reduce the automatic imitation effect, which would be reflected by a larger reaction time difference between congruent and incongruent trials.

Recent evidence from (Krebs & Woldorff, 2017b) demonstrated that motivation could modulate cognitive processes that subsequently facilitate automatic imitation, i.e., a larger response time difference between congruent and incongruent trials. Similarly, Krebs et al. (2010) observed that reward prospect improves processing of task-relevant information resulting in faster and more accurate response in a colour-naming Stroop task. A subsequent study by Krebs et al. (2013) observed event-related potentials (ERP) in a similar task paradigm. They found that behavioural facilitation in potential-reward trials was linked to early fronto-central and occipital ERP modulations, indicating increased attention for task-relevant stimulus components related to reward prediction. Furthermore, the attentional reinforcement appeared to regulate the temporal dynamics of conflict processing, allowing behavioural interference from task-irrelevant stimuli in potential-reward trials to be reduced. This finding is consistent with a study by Prével et al. (2021), which tested the effect of non-instructed prospects of monetary gains and positive affect stimuli on cognitive control using the AX-Continuous Performance Task (AX-CPT) in which participants to respond to a prompt (X) only when it is preceded by a cue (A) using either the left or right arrow-key to respond. The results showed a significant improvement in the task following positive outcomes (monetary reward and positive affective stimuli), suggesting that non-instructed outcomes possibilities may influence cognitive control. Therefore, we would predict that an SRC effect would appear under reward manipulation through an SRC task which measures the reaction time difference between congruent and incongruent stimulus-response trials.

On the contrary, if automaticity is independent of cognitive control processes, we would expect that automatic imitation would not be affected by motivation as is argued in several studies. Genschow et al. (2022) through a series of experiments including an imitation-inhibition in a finger lifting task reported that a group membership, i.e., in- and out-group memberships in a social environment did not affect automatic imitation. Despite not finding any social influence on automatic imitation, their findings have an influence on the motivational account of automatic imitation in social modulations as it posits that a sense of affiliation (group memberships) does not enhance motivation to imitate others in a social interaction. The generalizability of published studies concerning motivational influence on automatic imitation is still lacking and requires a systematic approach to contribute to the current motivational theories of imitation.

Present study

Nevertheless, most previous studies have yet to elucidate the role of motivation in modulating automatic imitation effect in an SRC paradigm. Subsequently, there are two aims in the present study:

I. To replicate the automatic imitation effect of congruent stimulus in an SRC finger tapping task from Brass et al. (2000) in an online setting.
II. Establish whether participants with a prospect of reward, i.e., monetary incentive (reward group) would perform differently than participants with no incentive (no-reward group) in the SRC task.

The goal of the research was to test the main hypothesis that the automatic imitation effect is stronger for participants with monetary incentives (reward group) compared to those without monetary incentive (no-reward group) in the SRC task. We predicted that if automatic imitation can be modulated by cognitive processes, an enhanced performance is expected, i.e., automaticity is more diminished in the reward manipulation compared to in the no-reward manipulations.

We utilized an online implementation of the SRC task to test our predictions. Automatic imitation was assessed through an SRC finger tapping task, which was a modified version of (Brass et al., 2000; Brass et al., 2001). To manipulate the reward group, we instructed our subjects at the beginning of the task that they would be rewarded with a bonus payment of £2 if they performed in the top 10 percent in terms of accuracy and speed. While the no-reward group was not given such monetary incentive, participants in this group were compensated the same amount as the reward group at the end of the study. We assessed the reaction time (RT) for a response following a prompt accompanied with a video distractor which could either match the prompted response action (compatible) or mismatch it (incompatible).

Methods

Participants

The study had initially recruited a total sample size of 151 participants through the Prolific platform. After subsequent drop-outs, opt-outs of the study, etc., only 83 participants (41 in the reward group and 42 in the no reward group) remained who successfully completed the study. We later excluded four additional participants from further analysis due to technical issues while completing the study, and another two for high error rates (ERs; See Table 1). The final analysis consisted of 39 participants in the reward group (26 females; mean age = 24.08 years, SD = 3.63), and 38 in the no reward group (28 females; mean age = 24.32 years; SD = 3.93). Participants gave consent of their participation, and were paid equally upon completion of the study. All were native-English speakers, no history of language related disorders, had corrected-to-normal vision, right-handed and 18 to 30 years of age. The study was approved by UCL's Research Ethics Committee with ethics code 15365.001.

Materials

The experiment was administered online on the Gorilla platform, where participants completed a SRC finger tapping task adapted from Brass et al. (2001) displayed on their computer screen. Participants were instructed to respond to prompts presented on a computer screen by a left or right arrow key press. As shown in Figure 1A, the symbolic cues ("!" and "#") were displayed simultaneously on top of a video distractor of upright index or middle finger tapping. The distractors matched or mismatched the key press response prompted by the symbolic cues. Congruency refers to compatibilities in perceived and performed actions, where the video distracter matches the prompt in a trial, while in an incongruent trial, the video distractor and prompt are mismatched. An attention check task was included to monitor participants' attention and active
participation in this online study. The task was embedded in the SRC task, whereby randomly once within each block a trial displayed either 3, 5, or 9 dots, and participants had to answer the number of dots displayed in the trial (see Figure 2). The trials were important to ensure that participants paid attention throughout the experiment.

The videos were filmed using a Canon Legria video camera and edited in Final Cut Pro. Clips were extracted representing the actor's left hand in a neutral position, with the left of middle finger down (see Figure 1B). The hand images were rotated 90 degrees counterclockwise and displayed as 50% of their original size. Each stimulus video lasted 3,000 ms, beginning with the hand in resting position for 500 ms or 740 ms (jitter) before finger movement (lasting 1000 ms), and ending with the hand in resting position (lasting 1500 ms or 1250 ms). The prompts were size 63, font Helvetica in white. The files were saved in .mov format before being exported as .mp4 files.

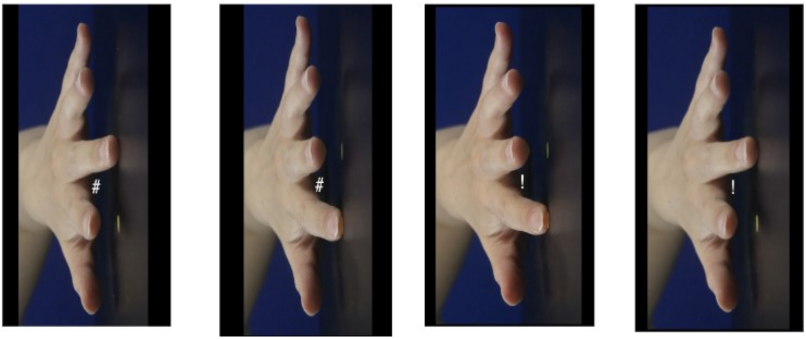
Table 1: *Exclusion criteria and numbers at each stage of the study*

Study stage	**Initial *n***	**Exclusion criteria**	***n excluded***
Main study	151	Withdrew from the study	57
		Did not complete the experiment	4
		Failed the attention check	7
		Total exclusions	**68** (45.03%)
Data processing	83	Error rate >3 SD from the group mean	2
		Technical issues during the experiment	4
		Total exclusions	**6** (7.23%)

Note. *n = number of participants; final n = 77 (39 in the reward group, 38 in the no reward group).*

Procedure

The study was conducted online entirely, in which participants completed a computer-mediated experiment. A between-subject design was employed to investigate the effects of congruency (congruent vs. incongruent) and reward condition (incentive vs. no incentive) on reaction times (RTs) in the SRC task. The task consists of six blocks of 40 counterbalanced and randomized trials each, which in total took on average 16 minutes to complete. Two versions of stimulus associations were created to counterbalance the symbol-action pair-



Congruent Incongruent Congruent Incongruent

Figure 1a. *Four possible end-frame of congruent and incongruent trials for "#" and "!" prompts in the first type of stimulus association.*

ings. The stimulus in the first association required a left arrow key press response to a "!" prompt and a right arrow key press response for a "#" prompt, whereas the prompt and response was reversed in the second stimulus association, i.e., a "!" prompt required a right arrow key press response. Participants were assigned to either one of the stimulus associations. Additionally, a prompt onset was controlled for at a jitter of 500 and 740 milliseconds after a trial begins to avoid any possible interference effects. Each participant participated in either the reward or no reward group. In the reward group, participants were told about monetary incentive (£2 bonus) if they performed in the top 10 percent in terms of speech and accuracy while the other group was not informed of such incentive. All of them were paid equally (£4 in total), regardless of the condition, at the end of the study.

The distinction between reward and no-reward groups was that, in the reward group, participants were told of the monetary incentive at the beginning of the task. In each group, participants completed the information sheet and consent form before proceeding to the task. Following this, the participants were informed of the SRC task structure together with training trials to familiarize themselves with

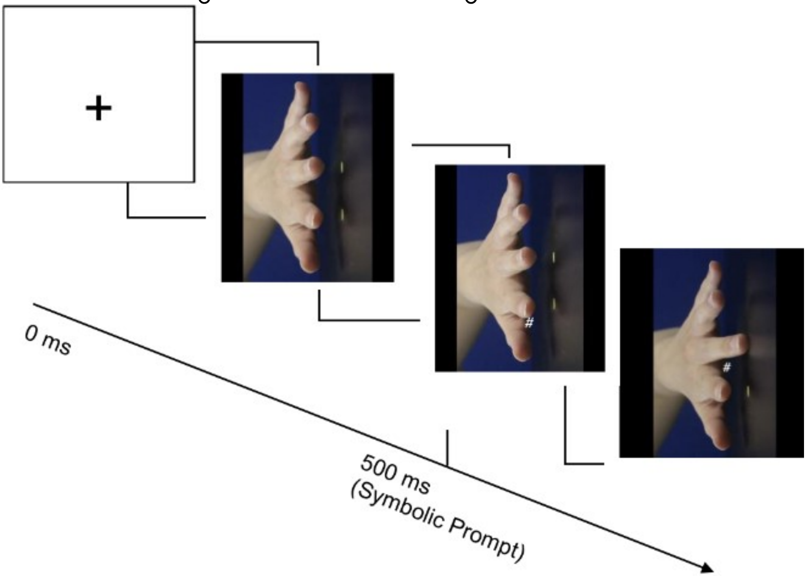


Figure 1b. *An example of timeframe of a congruent trial in a testing session for the first stimulus association, a "#" prompt and right middle finger tapping video distractor pair, with the prompt presented at 500 ms.*

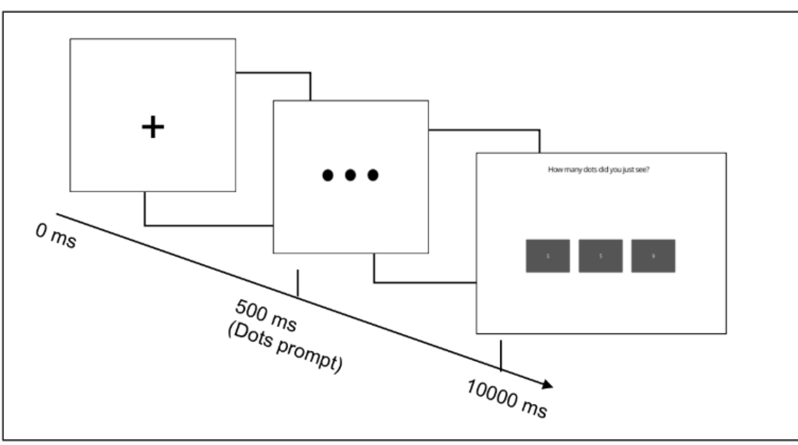


Figure 2. *A timeline of attention check trial presented after a series of SRC task trials. The video lasted for 10,000 ms, with the prompt presented at 500 ms. In the last frame, participants had to choose out of three options which matched the prompt displayed.*

the stimuli and compatible responses before proceeding to the test phase. In the first stimulus association, half of the participants were instructed to respond with a left arrow key press using their right index finger when a "!" symbol appeared, and a right arrow key in response to the appearance of a "#" symbol using the right middle finger. Video stimuli displayed a symbolic cue in between the right index and the middle fingers. In a congruent trial, a symbol "!" is matched with a right index finger video stimulus, and this prompt must be followed by a right arrow key press, signifying a compatible response (Figure 1B). In an incongruent trial however, a video stimulus is incompatible to a symbolic cue, i.e., an index finger tapping distractor was displayed for a "!" cue. Conversely, in the second stimulus association, the instructions of the prompt were reversed for the rest of the participants, i.e., they had to respond with a left arrow key press using right index finger when a "#" prompt appeared, whereas a right arrow key press response using the right middle finger when a "!" prompt appeared. Manual responses were recorded automatically, with RT being the onset of key press relative to the onset of response prompt. An accurate response was determined by a key press as indicated by a prompt shown in a trial.

Analysis

Participants with error rates greater than three standard deviations away from the group mean and participants who perform <=80% of 'catch trials' (three per block, 18 trials in total) were excluded from the analyses. Only correct trials were included in analysis, meaning that correct trials which fall within three median absolute deviations (MADs) from participants' median RT in each condition (for correct trials) were included, whereas incorrect responses and responses with RTs <200 ms or >1000 ms were removed from analysis. The effects of congruency (congruent vs incongruent) and monetary in-

centives (reward vs no reward) on the RT for accurate trials in the SRC task were investigated using a linear mixed model (LMM). A comprehensive model was structured to account for the random effect of by-participant random intercepts for all fixed factors and interactions, as well as congruency (congruent vs
incongruent), and monetary incentives (reward vs no-reward). In this approach, a forward model construction technique is employed, as recommended by Barr et al. (2013), starting with random effect only, with successive addition of a fixed effect and interactions until the best model is obtained. Then, an analysis of variance (ANOVA) test is conducted to determine if the best fit model significantly improved its previous model. Aside from the p-value based stepwise selection, the model with lowest Bayesian Information Criterion (BIC) value was chosen as it supported the model with better quality relative to another model, and it penalised model complexity more heavily than the Akaike Information Criterion (AIC; Rouder et al., 2016). The hypotheses of the study were:

I. The RTs for congruent trials would be faster than the incongruent trials, demonstrating an automatic imitation effect.
II. There would be a substantial difference in RT in the SRC task between the participants in the reward group and those in the no-reward group.
III. The automatic imitation effect would significantly be stronger in the reward group and the no-reward group.

It was predicted that the model with all main effects and interactions, as well as random intercept of participants would be a significant fit to the data. The key interaction central to our hypotheses was between condition and congruency, as it signifies whether the automatic imitation effect could be influenced by the prospect of monetary gains. The following information were recorded from each trial:

- Reaction time (RT): The time from the prompt onset (i.e., symbolic cue) to the time when the participant responds with a key press, measured automatically with Gorilla in milliseconds (ms).
- Accuracy: Whether a key press response matched the prompt given; 0 (incorrect) and 1 (correct)

Results

The data was exported from Gorilla (in a .csv format) and was analyzed with R (RStudio 2021.09.0 version). Prior to analysis, participants with technical issues, error rates >3 standard deviation (SD), and incorrect trials were excluded from the data. Additionally, the median absolute deviation (MAD) was calculated for each participant and condition, and RTs which deviated by 3 MAD were removed, as suggested by Leys et al. (2013). After the errors and outliers were omitted, RTs distribution were calculated for each condition, congruency, and jitter (see Figure 3 and Table 2 below).

Main Analyses

A linear mixed model (LMM) analysis was conducted in R using lme4 package and lmerTest package, which implemented the Satterthwaite's method to generate p-values for significance testing and degree of freedom estimates for mixed models (Bates et al., 2015; Kuznetsova et al., 2017). The model includes RT with conditions, congruency, and jitter as main predictors, condition and congruency as interaction terms, and the random factor of participants to test our hypotheses. We ran a first model with only a by-participant random factor to observe if random effects of participant influence the RTs prediction. Unlike previous studies (Genschow et al., 2022; van den Berg et al., 2014) which reported comparison of means for each group, the inclusion of random effects of participants would enhance our prediction of means and variance for a general population that were not part of this study. In this model, 43.81% of the variance is explained by the random effect of participants.

A similar model with addition of fixed effects of condition, congruency, and jitter was created. In this model, there were significant main effects of conditions (β= -30.18, t = -2.10, p = .0394), congruency (β = -8.69, t = -7.67, p < .001), and jitter (β = -0.089, t = -18.76, p < .001). The random effect of participants explained 43.40% of variance which was not explained by the fixed effect model. We compared the current model with fixed and random effects with the previous model with only random effect using ANOVA, which applied the maximum likelihood (ML) method for model selection. The purpose of the test was to determine whether a more complex model was significantly better to capture the data than a simpler model (Phillips, 2017). We found a significant result, p < .001, and lower BIC value, BIC = 183902, indicating that the addition of condition, congruency, and jitter fixed factors significantly improved the model fit.

We further tested the interaction between condition and congruency as these factors were central to our hypothesis that automatic imitation could be mediated by reward. In the third model, we fitted an interaction effect between condition and congruency. The results showed that the main effects were significant; condition (β = -30.31, t = -2.10, p = .0393), congruency (β = -8.81, t = -5.41, p < .001), and jitter (β = -0.089, t = -18.76, p <.001). However, the interaction between condition and congruency was not significant (β = 0.23, t = .100, p = .920). The random effect of participants in this model explained 43.39% of the variance which was not explained by this model. An ANOVA test was conducted to compare between this model with interaction of congruency and conditions. The result was not significant, p = .9203, this model with interaction term had a higher BIC value, BIC = 183911, hence, adding an interaction term of con-

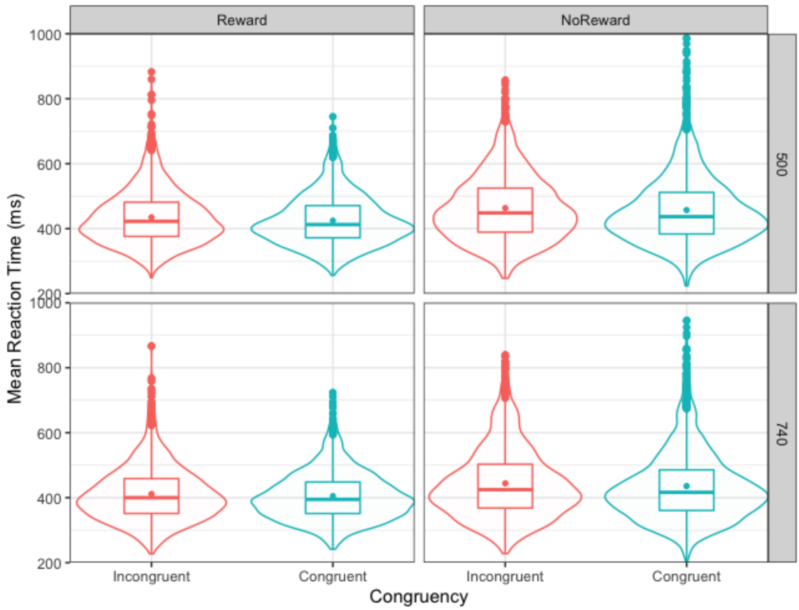


Figure 3. *Reaction times distribution in each condition, congruency, and jitter (the dots within each boxplot represented means).*

gruency and condition did not improve the model fit.

Taken together, the overall results suggest that the second model with fixed effects of condition, congruency, and jitter, with the random effect of participants, was the best model for our data. In summary, our results suggest no evidence of monetary incentives on the automatic imitation between the reward prospect and stimuli congruency, contrary to our prediction that the automatic imitation effect would be stronger for the reward group which received monetary incentive than the no-reward group.

Table 2: *Mean reaction times in milliseconds (ms), SOA = stimulus onset asynchrony or jitter, standard deviations (SD), and standard errors (SE) for each group*

Group		SOA (ms)	RT (ms)	SD (ms)	SE (ms)
Reward	Congruent	500	424.7	76.75	1.673
		740	404.8	74.14	1.620
	Incongruent	500	435.0	84.20	1.862
		740	411.4	85.15	1.874
No-reward	Congruent	500	457.2	109.2	2.482
		740	435.6	109.5	2.458
	Incongruent	500	463.3	102.7	2.340
		740	444.2	109.3	2.473

Discussion

The study's aim was to determine whether automatic imitation is stronger for congruent trials than incongruent trials in an SRC key-pressing task, and if this effect was modulated by a reward manipulation. The study adapted an SRC finger tapping task by Brass et al. (2000; 2001) in combination with a monetary incentive reward manipulation.

Automatic imitation effect

It was hypothesized that the RT for congruent trials would be faster in the congruent trials than the incongruent trials. Numerous studies have demonstrated the automatic imitation effect through an SRC paradigm, in which compatible stimulus-response pairings produced faster response times than incompatible stimulus-response pairings (Brass et al., 2000; Longo et al., 2008). This study found a similar effect of congruency to the present paper, in which the results showed a significant RTs difference between congruent trials than incongruent trials. These outcomes then provide general support for our hypothesis that there was an automatic imitation effect in the SRC task, reflected by a faster RTs in the congruent trials (compatible stimulus-response pairing) than in the incongruent trials (incompatible stimulus-response pairing).

A similar trend in the existing literature using the SRC task was that the spatial compatibility effects (where stimuli and response were spatially compatible to participants) could have passed the automatic imitation effect (Brass et al., 2000; Pan & Hamilton, 2015). The SRC task in our study was structured to control or at least minimize the compatibility effects through orthogonal presentation of video stimuli, allowing for a clear effect of automatic imitation. These results are in agreement with those obtained by Jiménez et al. (2012)

who also reported an automatic imitation effect after controlling for spatial compatibility effects using orthogonal stimuli arrangements. Overall, our findings successfully replicated the automatic imitation effect found in previous studies with the familiar SRC key-pressing task, as well as demonstrating this effect while controlling for spatial compatibility in a manner coherent with the study by Jiménez et al. (2012).

Another important finding was that RTs were significantly faster for jitter of 740 ms than 500 ms, when the prompt onset was displayed later relative to the video distractor. This result seems to be partially consistent with the other study on automatic imitation of vowels using the SRC paradigm (Adank et al., 2018). This study used a broader set of stimulus onset asynchrony (SOAs); with four SOAs, and found a greater automatic imitation in both experiments at the later SOA, i.e., SOA3. In this study, since there was no interaction between congruency and jitter, we could not conclude that automatic imitation was largest for a later jitter/SOA, hence the main effect of jitter explained that participants were better at discriminating incongruent trials when the prompt appeared later in a trial at 740 ms.

Prospect of reward does not influence automatic imitation

We hypothesized that there would be considerable difference in overall RTs between the reward and no-reward group. Our results support this prediction since there was a significant main effect of condition predicting RTs in the SRC task. The reward manipulation worked as intended, as the reward group who had the false belief that they were rewarded more, performed better. The results support a previous finding by Yamaguchi & Nishimura (2019), who investigated the influence of reward anticipation on a flanker task performance in which participants responded to the targeted colours stimuli while ignoring the accompanied flankers with identical colours. They found faster RTs were associated with the anticipation of performance-dependent rewards, which aligns with the present study where participants were instructed that the monetary reward would be granted for reaching performance levels in the top 10% of the study. Bianco et al. (2021), in their study of participants' engagement in online auditory tasks, also found an improvement in listening performance when a monetary bonus was granted, which is interestingly similar to participants' performance in a lab setting. Consistent with the literature, this research found that the participants in the reward group could have paid more attention to the task than the participants in the no-reward group. They also caution that, because online participants are unsupervised, anonymous, and motivated by monetary incentives, improving the quality of an online study is necessary to improve its reliability. The author also mentioned that the monetary incentives may have no influence if the task is too simple, or if the return on effort is low, i.e., it is difficult to improve performance (Bianco et al., 2021).

Nevertheless, the main focus of our study was to test the hypothesis that the automatic imitation effect was stronger for the reward group than the no-reward group. Our results, however, do not provide evidence for this prediction as the interaction between congruency and condition was not statistically significant. Previous studies have demonstrated mixed results with regards the effect of rewards on cognitive control. Padmala & Pessoa (2011) showed that trials which were cued with reward had a faster response speed, implying an increase in proactive control, which is consistent with previous findings that reward incentives improve attentional control and reduce conflict. This appears to not be the case in our study in which such effects were not detected.

Furthermore, we could argue that the automatic imitation is truly automatic, and not controlled regardless of reward manipulations. Research by Michałowski et al., (2017) adapted a go/no-go task, where participants had to quickly respond to a go signal and inhibit a no-go signal, with the addition of monetary incentives (rewards) in the instruction at the beginning of each trial, i.e., high, medium, or no rewards. They observed that the performance in the inhibitory go/no -go task did not differ regardless of reward magnitudes. As such, the effect of monetary incentives in the current study could have influenced performance in the SRC key-pressing task, but not significantly when the congruency effect was accounted for. In other words, automatic imitation in the SRC task may be independent of monetary incentives.

Limitations and future research

The first limitation of the current paper is the online experimental setup which might have failed to capture the effect of monetary incentives on automatic imitation. Indeed, several previous studies which explored the effect of reward on improvement of cognitive control were carried out in a lab setting (Prével et al., 2021; Yamaguchi & Nishimura, 2019). Perhaps, if the study was carried out in a lab, the results would yield a significant effect of reward on automatic imitation. The reason being was that in a lab setting, experimenters could monitor participants' engagement on the task, which otherwise was restricted in an online study. On that note, future online studies should check participants' performance across blocks of trials, whether there could be a diminishing performance due to fatigue effect from online studies. This might not be the case in this study as the experiment lasted for ~20 minutes on average. Despite the limitation, our study succeeded at capturing the automatic imitation effect, as shown by faster RTs in the congruent trials than the incongruent trials.

Moreover, the study only mentioned the monetary incentives once before the first block of trials in the treatment group. Krebs & Woldorff (2017), suggested an alternative reward paradigm in a form of feedback after each trial or block to participants. The distinction between reward prospect and reward granted context could heavily influence the performance in the SRC task. Thus, future studies should explore influences on automatic imitation under different aspects of rewards manipulations, such as high vs low reward magnitudes, punishment of incorrect response, and performance change when reward is granted for correct trials.

In this regard, potential future directions of research in this area were proposed. Future studies should first discern the automaticity of a behaviour, and what role awareness has in the cognitive processing of this behaviour. One of the main considerations of covert imitation of action is to discern the automaticity of behaviours, i.e., how does intentional control or unconscious process modulate an imitation and if it is possible for this to be understood through neuroimaging and event-related potentials based methods. Behaviourally, a similar experimental setup with multiple SOAs predicting RT in an SRC task could lead to a clearer distinction between automatic and deliberate cognitive control. Nonetheless, while these outcomes are an important step toward developing an integrated automatic imitation theory, they are currently largely unspecified at the process level. Furthering the current reward paradigm, by incorporating a broader and more diverse set of motivational factors, holds great promise for moving the field forward.

Conclusion

This study explored the influence of monetary incentives on automatic imitation. The results showed an overall automatic imitation effect, and an overall effect of monetary incentive on task performance. However, we found that the automatic imitation effect was not modulated by the monetary incentive. Further studies could explore the use of alternative reward manipulations to further explore how the mental processes involved in the SRC task differ from other tasks, such as the Stroop task and flanker task.

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