Cognitive mechanisms of being imitated

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Abstract

Being mimicked (BeMim) arises when one person copies the actions or choices of another person, and several studies link BeMim to liking and affiliation. BeMim effects might occur for matching of motor actions but have also been reported for the imitation of preferences and values. In this chapter we discuss various approaches to studying BeMim, from live interactions to controlled methods in the lab and from virtual reality to observation studies. We suggest that the fundamental cognitive mechanism that support BeMim effects are still unknown and it is not yet clear if various BeMim paradigms tap the same cognitive mechanisms. Three possible neurocognitive models of BeMim are considered: a specialised BeMim model; a universal model which is domain general based on cognitive predictability and a social learning model. The latter seems to be the most promising based on the current evidence. We highlight the non-monotonic character of the BeMim effects – there may be a 'sweet spot' where BeMim has positive consequences but too much or too little mimicry can mean that the mimicker's action is judged negatively rather than positively. People also dislike mimickers if they have awareness of being mimicking by them. Finally, we discuss the gaps in the BeMim literature that need to be addressed to move the BeMim field forward.

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1. Introduction

Imagine a social situation where Anna leans forward, scratches her eyebrow, and shifts her legs as she speaks, and shortly after Bob leans forward and scratches his eyebrow, and shifts his legs. Here, Bob mimics Anna's actions, probably without realising he is doing so. A number of research studies suggest that this mimicry behaviour is associated with liking and affiliation - that Bob and Anna will now feel closer and will like each other more. This chapter reviews this literature, with a focus on the methods used to study this and the parallels between mimicry of motor behaviour and mimicry of more abstract choices. We consider both positive and negative effects specifically in the case of the person who is *being mimicked* (Anna in the example above).

To avoid confusion between discussion of mimicry (as performed by Bob) and the situation of being mimicked (as experienced by Anna), we will use the term *BeMim* to refer specifically to the experience of Anna, and to experimental conditions which create a situation where a participant is being mimicked. The term mimicry can describe the actions of Bob or the global dyadic interaction of both people. The idea that mimicry correlates with affiliation is found in Condon & Ogston (1966) and Scheflen (1964) but attention towards this phenomenon rapidly increased with the publication of Chartrand & Bargh's (1999) landmark study on the Chameleon effect. That paper includes an explicit and well controlled test of the effects of BeMim, where a naive participant took part in a conversation with a confederate who copied some of the participant's gestures and movements. After the conversation, participants who experienced BeMim rated the confederates more positively than did participants who interacted with a non-mimicking confederate, providing evidence that there is a causal effect of the manipulation of the confederate's mimicry behaviour on the social perception of the participant.

One key point to resolve before we review the literature around BeMim is what should count as of mimicry or imitation. For some researchers (Boesch & Tomasello, 1998; Fridland & Moore, 2015; Heyes, 1994), the direct matching of bodily movements is a definitional component that distinguishes imitation from other forms of social learning. However, as noted by Heyes, (2021) the everyday use of imitation to refer to the copying of another's behaviour in general has been retained by researchers in fields such as behavioural ecology and cultural evolution as well as in the wider vernacular.

On this wider sense we can consider the imitation of others occurring across a range of levels, moving from the matching of motor actions at the most direct level through the matching of the outcomes of motor actions (often referred to as emulation) and then into increasingly abstract areas such as the matching of preferences and values (which is commonly referred to within the literature on social influence). In all these cases we can think of imitation occurring when one agent observes the behaviour of another and subsequently shows the same behaviour themselves and use BeMim to refer to the experience of being the copied agent. For example, if Anna says she likes Jazz and Bob replies that he does too, this might be perceived by Anna as a form of BeMim.

In recent decades, many different experimental methods have been used to explore the concept of being mimicked both at a motor level and an abstract level. BeMim is a challenging concept to study in the lab because it ideally requires a situation where person A spontaneously produces a distinctive behaviour or preference, person B then copies (or does not copy) that behaviour; afterwards the affiliation of A towards B can be measured. This can be characterised as a social learning task, as illustrated in Figure 1, where A has an initial impression of B which might be changed by B's behaviour (mimicking or not mimicking), and the new impression can then be measured by the experimenter. Typically, such studies also require a control condition where A engages in the same behaviours but is not mimicked; this could be a within-subjects design (e.g., A encounters a new person, C, who does not mimic) or a between-subjects design (a new participant encounters B who is instructed not to mimic).

For an experimenter wishing to study the effects of BeMim, the challenge is to create a scenario where A can behave naturally and then to implement the actions of B in an ecologically valid fashion. In various studies, B has been implemented using a confederate, using a virtual human, using a deceptive video clip (where participants believe the video is a live confederate) or using an 'ordinary' video clip (where participants are not deceived). In the study of shared preferences, there are also a range of different methods used. Some studies have examined shared preferences in the context of laboratory experiments in which participants simply learn about the traits of a target other without interacting with that target, while other studies involve examining levels of similarity within existing relationships (Montoya et al., 2008). Within laboratory studies, similarity of attitudes between self and other can be presented as having come about via chance e.g. (Farmer et al., 2019) or due to the confederate directly copying the participant (e.g., White & Argo 2011). Finally, the growth of social media and other forms of networked communication has allowed for researchers to identify the effect of shared preferences on the formation of large-scale social networks "in the wild" (e.g., Q. Ma & Hu, 2015)

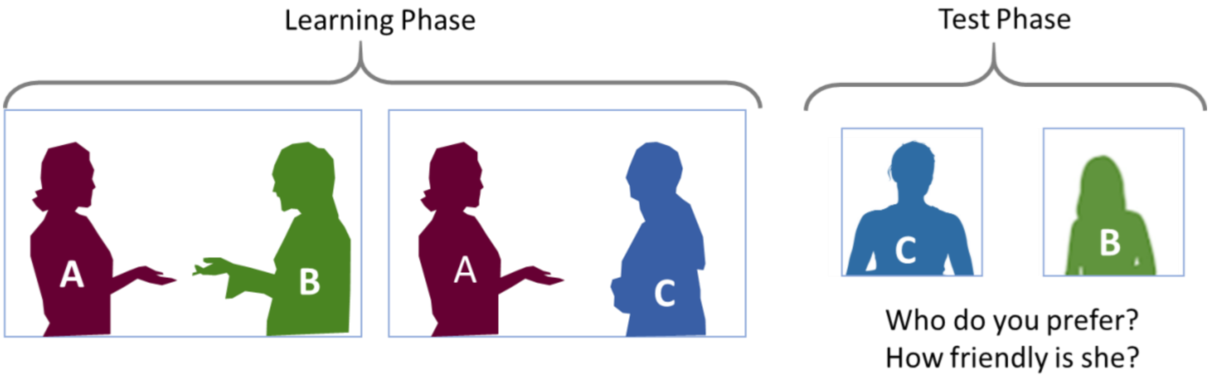

Figure 1. Experimental design*. A typical BeMim study has a learning phase where the participant (A) encounters confederates (B, C) who mimic (B) or do not mimic (C). After the learning phase is complete, the participant must evaluate the confederates in the test phase. This figure illustrates a within-subjects design but a between-subjects design, where each participant meets only one confederate who mimics or not, is also possible.*

In designing BeMim experiments, there are also some other important factors to consider. First, it is not always clear what is the most appropriate control condition. If a control condition is designed with reduced movement from the confederate in the interaction that might feel unnatural to the participants. If a control condition has movements of a different limb that are not mimicry, that might also feel unnatural. So, it can be hard to find an appropriate control. Similarly, another issue is whether BeMim effects arise only when there is precise mimicry between participant and confederate (the same limb performing the same action) or if more general contingent responses with any limb are enough to lead to BeMim effects. Some previous studies suggest that merely responding to another person's movement might be enough to induce the BeMim liking effect, without the need to mimic the same movements (Sparenberg et al., 2012; Kulesza et al., 2022). The implications of these results for our theories will be considered in the section about BeMim neurocognitive mechanisms.

To organise this review, we will divide studies up into four overarching categories, as illustrated in Figure 2. Some studies use tightly controlled interactions in the lab, such as moving in the same way as a person seen on video (Figure 2C) or preferring the same piece of art as an unseen person (Figure 2A). Others use live interaction between real (or virtual) humans who show similar motor movements (Figure 2D) or similar abstract preferences (Figure 2B). Each of these methods has advantages and disadvantages, and here we review work in each domain with a focus on evaluating methods. We do not provide an exhaustive review of all work using each method, but rather aim to highlight what can be done and what the limitations of each method are. In the second section of this chapter, we will then consider the broader implications and theories behind this work.

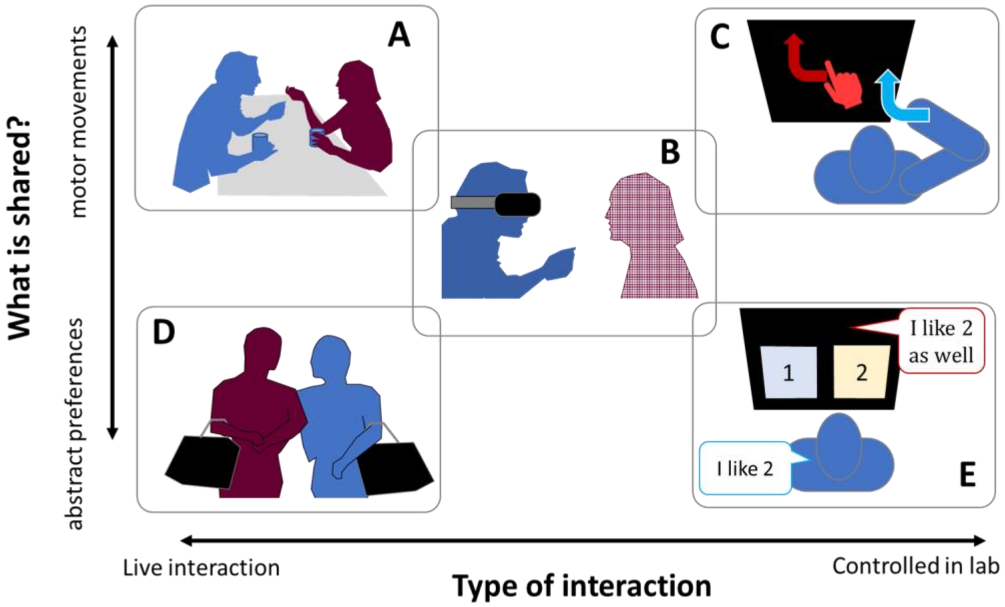

Figure 2. Ways to study BeMim effects *can vary according to what is shared (movements or preference) and the type of interaction (live or controlled).* ***A*** *illustrates a face-to-face conversation where movements are mimicked by a confederate (e.g., Chartrand & Bargh, 1999).* ***B*** *illustrates a virtual reality encounter where a participant is mimicked by a virtual agent.* ***C*** *illustrates controlled movement paradigms (e.g., Dignath et al., 2018).* ***D*** *illustrates consumer choices in live discussions.* ***E*** *illustrates controlled choices of abstract preferences (e.g., Farmer et al., 2019). In all cases, the blue figure represents the participant, and the red figure represents the confederate.*

2. Varieties of ways to study Being Mimicked

2.1. Studying motor mimicry in live interactions

The prototypical case of motor mimicry is a live conversation where one person copies (or does not copy) the actions of the other. In the landmark study of Chartrand & Bargh (1999), participants were asked to have a 15-min conversation about pictures with another ‘participant’ who was a confederate (a research assistant who is not aware of the hypothesis, but follows specific instructions on how to act). Here, the confederate was told to mimic the movements and posture of the participants during the conversation, and afterwards the participant's liking towards the confederate was measured using simple Likert-scale rating questions. Participants who were mimicked reported having a smoother interaction and liking the confederate more than participants in the control group who were not mimicked.

Numerous studies have recreated this type of confederate paradigm in in-lab or field research settings. For example, van Baaren and colleagues (2009) ran a similar study where each participant had a chat about advertisements with a confederate who mimicked (or not) their facial expressions, face/hair touching and feet/arms movements. The interaction lasted specifically 5.5. to 6 min and the mimicry was performed with a 4-second delay. After the task, participants were shown two pictures and asked how similar they find them. The data showed that mimicked participants saw more similarities between random objects than the non-mimicked ones. The authors claim that BeMim influences similarity from various perspectives: it makes people feel more similar to others, behave more prosocial, but also see random objects as more similar.

Other researchers conducted a study with live corporate interviews in the US exploring cultural differences between Latino and Anglo managers to BeMim response (Sanchez-Burks et al., 2009). Participants' gestures were mimicked or not by a confederate who was asking them personal questions about their career. Participants who were mimicked rated that the interview was better, answered questions faster and were evaluated as better than participants in the non-mimicry condition. In general, these results suggest that BeMim can provide a boost in confidence in a professional setting that results in actual better performance.

A very limited number of studies used a BeMim study design where anti-mimicry is included as a comparison. In a series of studies, researchers explored the role of physical attractiveness and BeMim in the sales context (Kulesza et al., 2014). The study was conducted in a cosmetic store, where the confederate pretended to be a salesperson who was welcoming and helping new clients. Confederates (with or without make-up) were instructed to mimic, stay still or anti-mimic in relation to the participant's movements. Results showed that mimicry made participants spend and rate customer service more favourably. 18 out of 19 all participants who said that they do not want to return to the store for future purchases were from the less attractive (without make-up) and anti-mimicking condition. This study suggests that BeMim positively influences purchasing behaviour and the effect is even stronger when the mimicker is physically attractive.

Another study explored whether BeMim creating motoric self-other overlap can be generalised to automatic imitation indices (Rauchbauer et al., 2020). During the picture description task, confederates mimicked or anti-mimicked participants' body movements with 3 to 6 s delay. They used participants' middle and index fingers in the Imitation-Inhibition task with congruent and incongruent trials to measure facilitation, inhibition, and interference of automatic imitation. Results showed only a decrease in inhibition index in a BeMim condition and an increase in an anti-mimicking condition; facilitation and interference index were not significant. Overall, this study showed that the self-other overlap after BeMim cannot be generalised to automatic imitation indices. This suggests that mimicry and automatic imitation are two separate cognitive processes.

There are both advantages and disadvantages to studying BeMim in live interactions. Conducting studies in these ecological settings allow researchers to study BeMim in an environment close to (or in) natural conversations, and as a result participants can act in a relatively genuine and spontaneous fashion, even in experimental situations. Live interactions can reveal behaviour patterns that would be impossible to study with more controlled experimental settings. It is especially relevant when it comes to studying the undefined unconscious nature of BeMim (e.g., Chartrand & Lakin, 2013; Chartrand et al., 2006). However, the biggest challenge of live studies is low experimental control – it is possible that other factors (besides motor mimicry) could influence the participant's affiliation feelings towards their interlocutor. Possible factors include the type and number of spontaneous (to-be-mimicked) actions produced by the participant, the background and training of the confederates, their knowledge of the hypothesis and the other movements and speech of the confederates that are not mimicry.

An ideal confederate would be able to hold the same conversation with every participant (regardless of that participant's characteristics) while mimicking specific aspects of the participants actions and not changing her smiles, eye contact, tone of voice or any other social cues. In practice, this is a very demanding task that requires excellent acting skills and self-control from confederates. Spontaneous behaviours like smiles or subtle differences in performing copying behaviour might not be well controlled (Fox et al., 2009). Furthermore, the amount of mimicry in an interaction depends on the interlocutors' tendency to mimic others, on differences between unique dyads and on reciprocity (Salazar Kämpf et al., 2018). This means that confederates might find it easier to mimic some participants than others. The confederate's initial liking of the participant (McIntosh et al., 2006), group membership (Bourgeois & Hess, 2008; Lakin et al., 2008), or personality traits such as extraversion (Duffy and Chartrand, 2015), and interdependence (van Baaren et al., 2009) could also influence how much mimicking behaviour confederates perform/produce.

Researchers can try to control these factors with manipulation checks such as using hypothesis blind video coders to capture differences in confederates' mimicry behaviour, and by evaluating their friendliness or smiling across the studies (Sanchez-Burks et al., 2009). However, these checks seem subjective – for example how can one objectively rate "[confederate's] apparent liking for the participant based on the video recording"?

Confederates can also fail at performing naturally. In some studies, researchers reported participants' or observers' comments about the confederates' exaggerated behaviour (Davydenko et al., 2020). This might cause participants to engage in atypical behaviour or make them guess the goal of the study or the fact that they interact with confederates. Moreover, confederates cannot be blinded to the key experimental manipulation (mimic / do not mimic), and they might have prior expectations about the study outcome which could influence the results. When confederates know about the study hypothesis, they might unconsciously change their verbal backchannels or nonverbal cues such as facial micro expressions, tone of voice, pauses, or eye gaze in a way that biases participants (Doyen et al., 2012; Gilder & Heerey, 2018). Researchers can limit such cases by providing to the confederates as little information about the hypothesis and the study design as possible. Ideally, they should be blind to the study hypothesis, purpose, design and if possible, how their behaviour is related to the variables (Kuhlen & Brennan, 2013).

A further challenge is that the cognitive demands experienced by confederates focused on mimicking cause changes in some aspects of social interaction dynamics (Hale & Hamilton, 2016). A confederate who is explicitly copying actions may not act in the same way as people in a real spontaneous interaction where mimicry is related to establishing affiliative bonds (Chartrand & Bargh, 1999), ameliorating a negative social situation – to make peace with someone (Rauchbauer et al., 2016) or to deal with rejection (Lakin et al., 2008). This might have influence on the interaction dynamic and BeMim response.

It is also difficult to determine if participants were (not) aware of the manipulation since study debriefing (asking participants what is the study goal after the experiment) is based on their declaration which could be influenced by social bias, how the question was phrased, and the assumed expectations. Some researchers offer financial incentives to the participants after the study if they correctly guessed if their interlocutor was a confederate or just a participant (Keysar et al., 1998; Keysar et al., 2000). However, this could make participants feel they have been treated unfairly if they do not guess the answer, which can discourage them from participating in future studies.

Finally, there is also a lack of consistency in terms of the non-mimicry condition. Most of BeMim research includes a control condition that assumes a neutral position throughout the task or/and a lack of copying behaviour (e.g., Chartrand & Bargh, 1999; Sanchez-Burks et al., 2009). For example, in Kühn et al.'s (2010) study when participants crossed their legs the confederates folded their hands or touched their hair. The design which includes an increased mimicry in a BeMim condition and a decreased mimicry in a control condition might give confusing results. There is a possibility it doesn't feel natural, and as a result, this might be the main driving factor for the results. However, there are also studies that define non-mimicry as anti-mimicry when confederate does opposite movements to the ones performed by the participant (e.g., Hasler et al., 2014; Neufeld & Chakrabarti, 2016). For example, when a participant leans forward, the confederate reacts by leaning backward. These different non-mimicry conditions might have different effects; for example, people spend significantly more money, wanted to revisit the store, and gave higher customer service ratings when they interacted with the non-mimicking salesperson in comparison to the anti-mimicking one (Kulesza et al., 2014). However, there are limited number of studies on the anti-mimicry effects which could be a new direction for the future research. For example, the question whether anti-mimicry drives any negative feelings towards the interlocutor (to our knowledge) remains unanswered.

Overall, studies of BeMim effects which use live face-to-face interactions are the closest to real world conditions and can provide an ecologically valid test of whether and how BeMim might impact on social evaluations and social interactions. However, it is hard to implement appropriate controls and results may be rather inconsistent (Hale & Hamilton, 2016). Thus, some researchers turn to virtual reality or to more tightly controlled experimental designs to understand the cognitive mechanisms of BeMim.

2.2. Studying BeMim using virtual reality

Virtual reality is an increasingly popular tool for gaming, real world jobs and psychological research. Within this domain, the creation and manipulation of virtual humans (who may or may not be presented in an immersive virtual world) is also a growing area. Virtual humans are computer generated characters who look, move and interact like real people. The creation and manipulation of virtual humans has massive potential for the study of social perception and affiliation, because the experimenter has absolute control of every aspect of the behaviour and appearance of the virtual human. In particular, virtual humans' studies allow the experimenter to define what type of actions are copied and what precise delay is present between the actions of the participant and the mimicry by the virtual human, which can be very useful for building and testing theories. However, there are several important challenges to researchers in this domain (Pan & Hamilton, 2018).

One of the most important is how the virtual human is controlled. Some virtual humans are avatars, which means they are controlled in real time by a real person and simply provide a virtual representation of that person's actions. Others are agents, which means they are fully controlled by a computer with no human intervention. In the game PacMan, the ghost are agents, while PacMan is the avatar of the player. Some virtual humans can be partially controlled by a person and partially by a computer or may be controlled by a human but without the other interaction partner realising this. This is called a Wizard of Oz setup (abbreviated to WoZ), because the participant believes they are speaking to or interacting with an autonomous virtual human (an agent) when in fact parts of the agent's behaviour are controlled by another person (e.g., a PhD student) pressing buttons behind the scenes. WoZ setups are typically used when it is too complex to program naturalistic behaviour into the virtual human, e.g., in conversations. These different control modes are important to the experimental design of BeMim studies and also have implications for how we interpret the studies.

The first study to create a virtual human who mimics a participant and use that virtual human to test for the impact of BeMim on social interaction was from Bailenson and Yee (2005). Their participants entered an immersive VR and saw a virtual human who gave a (prerecorded) persuasive message about campus safety and also mimicked (or did not mimic) the head movements of the participant with a 4 second delay. Participants who were not mimicked saw the virtual human make pre-recorded normal head movements. The group who experienced the BeMim condition rated the agent as more effective and had a more positive impression of the agent. Note that the 4 second delay was chosen based on a prior small study suggesting this was optimal to reduce detection of BeMim, but that 8 of 69 participants detected that the virtual human was mimicking (and were excluded).

Several other papers have examined whether BeMim from virtual humans leads to increased liking or affiliation. Hasler et al. (2021) created a detailed scenario where Israeli participants engaged in conversation with a virtual human who appeared to be Palestinian (i.e., outgroup member). The virtual human spoke in pre-recorded segments leaving time for the participant to reply, and also mimicked (or did not mimic) the posture of the participant (e.g., legs crossed / uncrossed). Both posture and speech timing were controlled by WoZ. After the interaction, participants who were mimicked reported more empathy, sympathy and liking for the Palestinian character. This shows positive effects of BeMim even during interactions with outgroup members. Positive effects were also seen in a study from Aburumman et al. (2022) in which a virtual human performed head movement during a picture description task. Mimicry parameters were closely modelled on Hale et al. (2020) with a 600 msec delay between the participant's head movement and mimicry by the virtual human, and additional nodding from the virtual human when the participant was speaking. Participants interacted with two virtual humans and gave more positive ratings to the one who showed mimicry. These studies show that it is possible for well controlled mimicry of head movements by a virtual human to lead to increases in liking in a context where all other social parameters are held constant.

However, not all studies in this area have positive results. In one study, researchers created a virtual human who mimicked a participant's head movements while explaining the rules of an investment game. Participants who interacted with the mimicking agent did not show more trust in that agent during the investment game, unlike previous studies. However, they did like and trust the mimicking agent more in a second route-planning task (Verberne et al., 2013). Null results were found in a study from Hale and Hamilton (2016) which created a virtual human who could perform a 'picture description task' with a participant, that is, the participant and the virtual human took turns to describe a picture to each other. During the task, the virtual human mimicked the participant's head movements (excluding large movements to look down at the picture) with a 1 or 3 second delay. Experiment one found marginal positive effects of BeMim on rapport ratings, and that 30% of participants detected the mimicry when the delay was set to 1second, while only 4% detected it at 3 seconds. Experiment two was a pre-registered replication of this with an additional ingroup/outgroup manipulation which found null results. In a study from Choi et al. (2017), participants interacted with a telepresence robot who showed no mimicry or head movement mimicry (500 msec delay) among other conditions, but no positive effects of mimicry were found either. Ghazali et al. (2019) used an interactive robot who completed several tasks with a participant. During the tasks, the robot could show no mimicry, head movement mimicry or head movement mimicry plus verbal praise. They found that participants had positive responses to the robot in the BeMim verbal praise condition but there was no clear difference between no mimicry and mimicry alone. The authors interpreted this in terms of increasingly rich social cues leading to increased liking.

To summarise, of 7 published papers which directly examine BeMim effects using virtual humans, 3 report positive effects, 2 report mixed effects and 2 report null effects. This suggests that BeMim effects in virtual humans are fragile and hard to study. One possible explanation could be that our ability to create believable virtual humans and have them interactively engage with participants is too limited, and that as we gain a better understanding of real-world mimicry and better generative models for human social behaviour, we will be able to build virtual humans that show high quality mimicry behaviour and observe the positive impacts on participants. Another explanation could be that BeMim alone is not enough to cause positive effects, and that many of the effects reported in real-life confederate studies might be false positives. Stronger pre-registered replications of the most robust BeMim paradigms would be very valuable.

2.3. Studying motor BeMim with controlled movement paradigms

Traditional cognitive psychology studies in which participants experience many similar trials of a computer-controlled paradigm provide an alternative approach to the study of BeMim. Here, in the learning phase the participants perform an action (typically following the computers instructions) and then see an image or video of another person perform the same (or a different) action. A test phase involving questionnaires, or a more complex evaluation task is then used to determine how the learning affected the participant’s attitudes towards the images or social cognition in general. These tightly controlled studies allow experimenters to manipulate specific factors such as timing and contingency.

For example, Catmur & Heyes (2013) used computerized mimicry to study pro-social effects of BeMim and the role of similarity and contingency in it. The participant's task was to lift their hand or foot while seeing a video of a lifting hand or foot on the computer screen, and participants were placed in one of four groups with high/low contingency and high/low similarity. Those in the similar groups saw a hand movement on the screen being lifted when the participant lifted their hand; while those in the dissimilar groups saw a hand movement on the screen being lifted when the participant lifted their feet. Those in the contingent groups made a movement which was followed by an action on the screen in 100% of trials, while for those in the non-contingent groups, their own action was followed by an action on the screen in 50% of trials. Participants' attention was controlled by asking them to say "yes" when they saw a hand or foot rotated by 45 degrees. After the task was completed, participants in contingent groups (regardless of similarity) enjoyed the task more, felt closer to a random other person and were more willing to help the researcher (measured by asking to sign up to a follow-up experiment). This implies that the positive effects of BeMim arise because of a basic contingency between self-movement and the other's movement, regardless of whether that movement is actually mimicry. Other studies also showed similar effects indicating that merely responding to another person's movement might be enough to induce the liking effect, without the need to mimic the same movements (Sparenberg et al., 2012; Kulesza et al., 2022).

Controlled tasks can also be used to explore facial mimicry effects. In a series of studies from Neufeld and Chakrabarti (2016), participants were asked to perform happy or sad facial expressions followed by short clips of faces mimicking them or anti-mimicking (showing an opposite facial expression). EMG data recording was used to check if participants performed the correct facial expressions. Here, an implicit preferential looking task was used as an outcome measure of the social learning, rather than the more common questionnaire measures. First, participants were eye-tracked (baseline), and afterwards while seeing static faces of the two actors, one who previously mimicked their facial expressions and the other one who did not. Evidence for a learning effect was found because the gaze was biased towards mimicking faces and was also associated with positive evaluation through ratings of attractiveness and likeability. Moreover, after the conditioning task, participants with higher trait empathy showed greater gaze bias to the mimicking faces versus the anti-mimicking ones. The results reported here suggest that BeMim influences mimickee's gaze patterns and the effect is even stronger for people with high empathy traits.

The role of contingency was also tested in a study by Dignath and colleagues (2018). Here, participants saw a cue to action, performed an action and then saw a video clip of another person performing the same (or a different) action, thus creating BeMim conditions. Different video confederates were present in different blocks and produced mostly matching actions or mostly mismatching actions. Results showed higher affiliation ratings towards video confederates who mimicked. A second experiment manipulated the delay between participant's actions and the video starting, ranging from 0-3 seconds and found higher affiliation ratings for short delays. These studies suggest that both contingency and temporal proximity are important for BeMim effects.

A similar experiment was conducted by De Coster (2014). It started with a resting phase, where participant placed their right hand on a custom-made response box while watching a resting right hand on a video clip. Then, the action phase started, where a participant was asked to move one of their fingers which resulted in showing the video of a confederate doing the same movement in the mimicry block or a different movement in the non-mimicry blocks with no time delay. After each condition a video clip showing a pain scenario was presented followed by empathy related questions. The results showed that participants felt more empathy for pain in the mimicry condition than in the non-mimicry block.

The studies of effects of BeMim in highly controlled environments allow researchers to focus on specific factors such as contingency or spatial features. Well-controlled BeMim designs allow researchers to eliminate numerous challenges that come with performing mimicking actions by confederates such as action quality and their number, their knowledge about the mimicry mechanism or the study, as described in detail earlier in this chapter. Many motor BeMim studies use within-subjects designs which can reduce individual differences and provide greater statistical power. Here, the study's success does not depend on human factors, but on upon the design of the experimental paradigm. Moreover, using video stimuli offers an opportunity to test numerous participants in an online setting (Kulesza et al., 2022). Getting a high-powered sample is challenging for live interactions, thus, using video paradigm online with large samples in highly controlled lab settings seems very promising for future BeMim research.

However, the spontaneity element is removed from these tasks which changes the social interaction dynamics. Often participants are instructed to perform a chosen action which could be mimicked, rather than having a free choice of many possible actions as in a conversation. This is especially challenging since BeMim is a spontaneous social mechanism. The question is whether researchers still study the same mechanisms if they remove participants from the social context and try to control behaviour as much as possible with timings, number of repetitions, computer generated instructions, pictures, and videos. For example, in many of the studies reviewed above, the time delay between the participant's action and the BeMim action is very short and unlike natural social mimicry which has a much longer time course. As a result, these very fast events might tap into different cognitive mechanisms. For example, the studies using the Imitation-Inhibition task which is a potential controlled paradigm of BeMim showed that the automatic imitation and BeMim might tackle different cognitive processes (Rachbauer, 2020). Another challenge with highly controlled environments is a risk of participants being aware of the manipulation. The tasks are performed outside of the social context (contrary to live interactions) which means it could be easier to guess the BeMim study design and the goal of the study.

3. Mimicry of abstract preferences

So far in this paper we have concentrated on forms of being mimicked that involve the direct copying of the motoric actions of others. In this section we discuss research into the cognitive mechanisms that underly the recognition of, and reaction to, imitation in this wider sense. In the rest of this section, we will focus on the literature around the more abstract cases of BeMim, particularly the imitation of preferences and values.

The issue of how we learn and are influenced by the similarity of others' preferences to our own is a key one for researchers in fields as diverse as psychology (Lee & Chung, 2022), evolutionary theory (Jones & DuVal, 2019), sociology (McPherson et al., 2001), and consumer marketing (Dholakia et al., 2004; Chloe Ki et al., 2022). In all these disciplines there has been great interest in the question of social influence, how discovering the preferences of others can lead to a change in one's own, with a vast proliferation of research on the structure of social influence and the factors that increase influence (Izuma, 2013; Chloe Ki et al., 2022; Lee & Chung, 2022; Schnuerch & Gibbons, 2014). However, as with research around motor imitation, there has been much less interest in the effects of being the target of preference mimicry.

Unlike in the case of motor imitation, where it is usually possible to ascertain the direction of imitation due to the imitation being closely related in time, research on BeMim in preference imitation is complicated by the fact that, it can often be hard to separate out the effects of direct social influence from that of homophily or "love for similar others". The presence of homophily complicates our understanding of how BeMim for preferences modulates social affiliation as it can be difficult to know whether any specific example of shared preferences is due to one partner in a dyad actively copying the other or whether the partners have affiliated together because they shared a pre-existing preference.

3.1. Controlled studies of abstract preference mimicry

To date relatively few studies have directly examined the effect of BeMim for preferences. However, several studies have sought to examine the effects that learning other's share our preferences via controlled studies that manipulate the degree of similarity between self and other. To the extent that such participants perceive the choices of others as being dependent on their own choices these might be perceived as instances of BeMim.

Farmer et al. (2019) had participants learn the aesthetic preferences of two target others: one of who shared their own preferences 75% of the time and the other of whom differed from them 75% of the time during an fMRI scan. The authors then applied a reinforcement learning model to show that information about accumulated similarity was stored in an area of the dMPFC a region commonly linked to processing the relationship between self and other (Flagan & Beer, 2013). In line with findings of the positive effects of similarity, the similar target was also rated as more likeable and trustworthy than the different one.

While Farmer and colleagues examined how shared preference learning affects dyadic relationships between individuals, Gershman and colleagues (2017) used latent structure learning models to show that the effects of shared preferences on social bonds extend beyond dyadic interactions and plays a role in defining group boundaries. Gershman et al. demonstrated this in a series of studies in which participants first learnt about the film preference of two targets, one of whom shared 75% of their preferences (e.g., Alice) and the other of whom shared 25% (e.g., Bob). Participants then learnt about the preferences of a third person (e.g., Carl) who shared 50% of their preferences with the participant but 75% with one of the targets. They found that if this third person shared preferences with the similar target (e.g., Carl and Alice) then the participant treated them as an ingroup member while if they shared preferences with the target who had a different preference to the participant (e.g., Carl and Bob) they were treated as an outgroup member. Further studies have replicated this result for political views (Lau et al., 2018) and identified the right anterior insula as encoding the latent structure revealed by these different groups (Lau et al., 2020). Overall, these studies show that learning others share our preferences plays a role in the formation of social bonds at both the interpersonal and group level.

Other studies have examined factors that modulate the effect of shared preferences on affiliation. Several studies have found that learning that one's preferences are shared by disliked or dissimilar others can motivate a change in preferences either to as a means of signalling a distinct social identity (Berger & Heath, 2007; Berger & Heath, 2008) or to avoid being associated with an undesired reference group (Izuma & Adolphs, 2013; White & Dahl, 2006). For example, Izuma and Adolphs (2013) found that participants increased their preference for a t-shirt image when they learned that image was also liked by a liked group, i.e., students at the same university but reduced their preference when they learned the images was also liked by a disliked group, i.e., sex offenders. In addition, the degree of cognitive imbalance on different trials correlated with activations in a region of the dorsomedial prefrontal cortex (dmPFC) commonly linked with self-processing. The authors interpreted this finding in line with the theory of cognitive balance (Heider, 1946, 1958) which argues that our attitudes towards objects, other agents and those agents' preferences towards the objects must be consistent.

In addition to the identity of the people or groups who share our preferences our response to discovering shared preferences can also be modulated by the nature of the preference shared. Lab based studies manipulating the nature of shared preferences have found that people show greater affiliation to those who share rare, as opposed to commonly held preferences (Alves, 2018; Vélez et al., 2019). There is also evidence that the valence of the shared preference is relevant, with people reporting more positive attitudes towards those who liked the same things they liked than they did towards those who disliked the same things they disliked (Zorn et al., 2022). Finally, the basis for the effects of shared preferences in domains such as music on affiliation are driven by participants' assumption that shared preferences are an indicator of shared values more widely (Boer et al., 2011).

Studies of shared preferences using controlled designs typically involve a computerised task in which participants learn the preferences of target people who they do not directly interact with. This design allows researchers to have full control of the target's behaviour and choices and to remove confounds such as past social interactions, knowledge of the target's wider preferences and other aspects of their social identity. It also allows participants to precisely manipulate the number of shared preferences so as to explore different similarity levels. It is also easy to have a large number of different targets who are encountered and compare them. However, to date such learning have not directly manipulated cases where participants perceive the targets as simply happen to share their preferences from cases where targets are perceived as mimicking the participants responses. Future research that explicitly compares these two situations is needed to allow us to disentangle the effects of BeMim from those of homophily.

In contrast to body movements, cognitive abstract choices seem easier to control. One challenge is to quantify the similarity - for example, how much preference mimicry means "being highly similar" - 70% or 90%? At the same time the greater the overlap in preference, the more likely it is that the participant will guess either the goal of the study or the manipulation, which might change the results, although at present no study has directly measured this. Thus, there is a challenge to induce a feeling of similarity between the participant and the agent, but still not make the manipulation obvious to the participant. Moreover, similar to motor BeMim studies, it is difficult to study preference mimicry outside of a specific social context. Finally, these controlled studies could be criticised for being not social enough - participants do not see or interact with any real people and so might be more likely to use non-social mechanisms to make decisions.

3.2. Studying BeMim for Preferences "In the Wild"

As well as lab-based studies, other researchers have used observational data from real social groups to examine factors influencing the similarity-affiliation link. For example, Bahns et al. (2017) collected data on a range of personality traits, attitudes, and behaviours from over 1,500 pre-existing interacting pairs. The authors found that the perceived importance of an attitude was a key moderator of the amount of dyadic similarity, i.e., how much similarity there was between that attitude for the individuals in each pair. This indicates that people are more likely to affiliate with others based on preferences they judge to be important. Indeed, an additional analysis showed that ratings of attitude importance was just as strong a predictor of dyadic similarity as were the actual attitudes themselves. Cullum & Harton (2007) found similar results when surveying college students living in halls of residence. They found that, across the semester, cohabiting participants increased their attitudinal similarity and that the greatest increase in similarity occurred for attitudes the participants considered the most important.

Finally, the growth of social media and large-scale communication networks since the turn of the millennium have given researchers access to a rich new source of data which can be used to study the links between shared preferences and affiliation. Ma et al. (2015) examined the purchasing and call data on caller ring-back tones (CBRT), a form of personalised dial tones heard by those calling the purchaser which are commonly used across Asia. So if Alice purchases a specific CBRT that plays a piece of music then when Bob calls Alice he will hear that music until she picks up. Ma et al. used the combination of purchase data, i.e. who paid to apply a particular CBRT, and caller data, i.e. which CBRTs people had heard when they called others, to model the role of both latent homophily and mimicry, in explaining similarity between consumers in their choice of CBRT purchase and found a considerable role for each. Other studies have used social media networks to similarly quantify levels of homophily and mimicry in social media use (Noe et al., 2016; Šćepanović et al., 2017).

This short review shows that there is correlational evidence for both homophily and social influence ‘in the wild’. People tend to affiliate more with those who are similar and become more similar to those they affiliate with, but there is no specific evidence that preference BeMim alone causes liking. Indeed, as we lay out in here might be various cofounding factors influencing these results making it difficult to specify cause and effect. Future studies in this area should aim to create realistic social situations in which a participant makes a choice and then is mimicked (or not) by another person and then measure the effects of that abstract mimicry on feelings of affiliation between the participant and this other person.

Method	Description	Pros	Cons	Example Research Questions
Picture Description Task	A conversation about pictures with a confederate who is believed to be a participant. The confederate mimics (or not) the movements/posture of the participant	Ecological settings: participants can act spontaneously	Low experimental control, e.g., confederate's knowledge and acting skills	Does the BeMim effect arise in live interactions and why?
Virtual humans	Tasks that involve combining live tracking of participant's movements with virtually generated characters to allow those characters to imitate participant's actions	High experimental control - e.g., defining the type of actions copied and what precise delay is present between the participant's actions and the mimicry by the virtual human.	Challenging to create believable virtual humans and have them interactively engage with participants; the results might differ from studies on humans	Does the strength of BeMim effects depend on the time delay in copied actions?
Video clips	The participant performs an action (typically following the computer's instructions) and then sees an image or video of another person copying (or not) the same action	High experimental control - all challenges connected to human factors are removed; Opportunity to test numerous participants in an online setting	The settings aren't social - participants cannot act spontaneously; The goal of the study might be more visible to the participants	What is the role of specific factors such as timing and contingency in BeMim effects?
Preference Indication	A computerised task where the participant makes a choice (e.g., about pictures) followed by a target's choice. The experimenter has control of the target's behaviour and choices	High experimental control - precise control over the amount of similarity; Easy to implement.	The settings aren't social - participants cannot act spontaneously; Hard to distinguish the effects of homophily from the BeMim effects	Does the strength of BeMim effects depending on the number of shared preferences?

Large-scale social networks in the wild	Observational data (e.g. purchasing information, social media connections) from real social groups to examine factors influencing the choice similarity-affiliation link	Large samples of real-life data, strong ecological validity	Many confounding factors make it difficult to specify cause and effect	What are the links between shared preferences and affiliation?
Creative task	The participant performs a task with some creative element e.g., object customisation or colouring in a shape and compares their work with that of confederates who complete the task after them	Naturalistic and ecologically valid task. Allows for variation in the extent of imitation.	It can be hard to identify exactly which aspect of imitation produces the result.	Does the BeMim effect arise in creative tasks?

Table 1. Summary of methods to study BeMim.

4. Potential neurocognitive mechanisms of BeMim effects

The review above describes a range of studies of BeMim effects which use a wide variety of methods. The range from naturalistic tasks such as conversation to tightly controlled tasks such as a single foot movement, and vary from copying of motor actions to copying of more abstract choices of art. While all of these can be described under the overarching concept of 'being imitated', it is not clear if they all engage the same cognitive mechanisms, nor what those mechanisms might be. In this second half of the chapter, we lay out three distinct models of BeMim which vary in their amount of generality. Model 1 posits as specialised neurocognitive system attuned to motoric forms of BeMim while Model 2 considers the effects of both motor and abstract BeMim to be subcases of a wider form of social learning, Finally Model 3 takes the most domain general approach viewing the consequences of BeMim to depend upon universal mechanisms relating to stimuli predictability. We then consider empirical evidence that could distinguish between these models focusing on the how awareness of BeMim and timing and the cases where BeMim might have a negative impact on social interactions.

4.1. Model 1: A specialised mechanism for motor mimicry and BeMim.

Implicit in many discussions of the link between motor mimicry and affiliation is that there must be a specialised cognitive mechanism that underlies this, a social glue that is specific to motor mimicry (Chartrand & Lakin, 2013). In terms of neural systems, the most plausible candidate would be the mirror neuron system (Rizzolatti et al., 2001; Rizzolatti & Craighero, 2004), which responds when a person sees an action and performs the same action (imitation). Given the properties of mirror neurons themselves, it seems sensible to suggest that this brain system might also be engaged if participants perform an action and later see the same action (BeMim), though this has rarely been directly tested. Indirect evidence comes from Kilner et al. (2009) who had participants see and do actions in different sequences and found overlapping engagement of inferior frontal gyrus in both.

One study (Hogeveen et al., 2015) used EEG recordings of the mu-rhythm, which is considered to be a marker of mirror neuron system (MNS) function, to examine BeMim effects (later studies showed that using mu-suppression to examine MNS is unreliable (Hobson & Bishop, 2016). Participants were asked to do a "music-rating" task in a dyad or alone on the computer. Specifically, they were assigned to one of the 3 conditions: interaction with a mimicking confederate, an anti-mimicking confederate, or no social interaction at all (doing the task on the computer). They recorded participants' brain activity before and after the task while they were watching a simple video showing action execution. Mu-rhythm suppression was taken as an indirect index of MNS activity. They found an increase in mu-suppression after the task in the mimicry condition in comparison to the no-interaction one; the anti-mimicry manipulation did not lead to a change in mu-suppression. This data suggests that BeMim during social interaction results in enhanced MNS activation afterwards, during subsequent action watching.

However, there is also evidence that brain regions outside the MNS are important in BeMim contexts. In a study from Brass and colleagues (2009), participants performed index finger or middle finger movements during fMRI and saw an image of a hand doing a congruent or incongruent finger movement after a short delay. Results showed engagement of temporoparietal junction and mPFC for delayed BeMim conditions, which the authors linked to self-other differentiation. In a neuroimaging study of BeMim in autistic and neurotypical participants, Okamoto and colleagues (2014) found engagement of extrastriate body area (EBA) when being imitated, with less activation in the autism group. EBA is localised within the occipito-temporal region and is activated when looking at the human body and its movements (Downing et al, 2001; Astafiev et al., 2004). Overall, there is not enough evidence to specifically localise BeMim effects to one particular brain system, and it might be more helpful to consider them as part of a wider network of regions engaged in social cognition and social interaction.

4.2. Model 2: BeMim as a form of social learning

A second category of models suggests that there are general 'like-me' mechanisms that apply only to other humans (not to cell-phones or cars or trees) and that people use to learn about others and to prefer other people who are more 'like-me'. Such systems are not restricted to motor mimicry but are part of a more general social learning system for acquiring knowledge about other people and other groups. In these models, detection of similarity between self and other would employ some shared systems across motor and non-motor domains and link into other neural systems involved in both domain general learning and social cognition. On this account, all studies of BeMim effects could be characterised as social learning studies, whereby participants experience particular actions of behaviours from a confederate or partner, and thereby learn to update their estimation of the character or self-similarity of the confederate.

An expansive version of this type of model is given by Haun and Over (2015), who survey a wide literature to argue that a general preference towards similar others, i.e. homophily, is an evolved innate trait that drives the development of key drivers of human cultural transmission including motor imitation, conformity, and the formation of psychological norms. In support of their position, they note evidence for the existence of homophily in non-human primates (Paukner et al., 2009) and for the early development of homophily in children with evidence that young children not only prefer similar others (Gerson et al., 2017; Mahajan & Wynn, 2012) but also expect others to show that same preference (Bian & Baillargeon, 2022; Liberman et al., 2021).

Additional evidence in support of this model can be found in studies that examine BeMim in relation to in learning and reward. Following on from the behavioural studies described above, Hsu and colleagues (2018) used their facial mimicry task to explore differences between participants with autism and neurotypical participants. They used a mimicry conditioning task, where participants were asked to perform happy or sad facial expressions followed by short clips of faces mimicking them or anti-mimicking (showing an opposite expression). In the test phase, participants saw static images of the same people with neutral faces in the MRI scanner. The neurotypical group showed higher likeability ratings and a higher ventral striatum response to mimicking faces in comparison to anti-mimicking faces. The autistic individuals had an opposite pattern: a reduced ventral striatum response to mimicking faces in comparison to the anti-mimicking ones. This study confirmed the link between BeMim and the reward system and showed how it is affected by autistic traits.

Studies investigating more abstract versions of similarity have also found evidence linking similarity learning to brain regions involved domain general reward processing and regions specialised for social cognition. Farmer et al. (2019) used fMRI to track brain activity in a context where participants could choose which painting, they prefer from a pair and then subsequently saw the art preferences of two agents, one of whom mostly had similar preferences and the other most dissimilar preferences. Brain activity patterns were modelled in terms of prediction errors for choices on each trial, that is, how well each agent conformed to the pattern of their previous preference similarity. Results showed that areas of the caudate linked to domain general reward learning were activated by positive prediction errors, i.e., when the agent made a choice that conformed to their overall pattern of preference similarity (either similar or different). By contrast when an agent made a choice that elicited a negative prediction error, i.e., that was more inconsistent with the agents' overall preference similarity to the self than predicted, this led to activations in a range of brain regions linked to social cognition including dmPFC and temporal-parietal junction (TPJ). Lau and colleagues (2020) also used computational modelling to map brain areas involved in similarity learning and linked similarity between self and other to the anterior cingulate cortex, a brain region that has been implicated in the learning of reward for both self and others (Apps et al., 2016).

To summarise, the social learning models of BeMim suggest that detecting and processing the similarity between self and others is a general feature of learning about people. Such mechanisms apply across a range of different types of mimicry (both motor mimicry and abstract choices) but are specific to learning about humans and could not be expected to apply to learning about objects or other physical events in the world.

4.3. Model 3: Universal predictability

A third possible model for BeMim effects looks towards more general brain and cognitive mechanisms that apply across all domains, not just social interactions. Several lines of research suggest that events which are fluent or predictable are easier to process and potentially more rewarding than events which are disfluent or unpredictable (Oppenheimer, 2008; Reber et al., 1998). This applies to perceptual tasks (Reber et al., 1998) but also to motor tasks. For example, priming actions increases fluency and the sense of agency (Chambon & Haggard, 2012), and can even influence purchasing decisions (Chen & Lin, 2021). Even very young infants show a preference for performing actions which lead to a contingent predictable effect (Watson, 1972). It has been proposed that even young infants have a 'contingency detection system' (Gergely & Watson, 1999) which allows them to determine which events in the world (both social and non-social) are caused by their own movements, and thus to learn to interact with and control the world. In adults, sense of agency over motor actions decays with delays of just 200 msec (Farrer et al., 2008), while if the participant performs an action and then an effect (a visual image) is delayed by more than 4 seconds, participants do not judge that they have caused the effect. This implies that predictability/fluency works best at very short timescales.

Under this type of model, people enjoy and find reward in actions which result in predictable effects, so if A's hand action causes B to move his hand, A will find B's action predictable (on a neural level) and thus more rewarding than if B were to do a different action. Crucially, the same mechanism would apply if A's finger action caused a predictable non-social effect (eg.: open an app on a touchscreen phone), which would be more rewarding than if the same action caused an unpredictable effect or no effect. The central claim here is that any predictable action-effects, both social and nonsocial, are linked to reward, and that BeMim effects can be subsumed within the much larger category of predictable effects. Evidence in favour of this comes from the study by Catmur et al, in which participants preferred contingent responses to their own movements to non-contingent responses regardless of the motor matching (Catmur & Heyes, 2013). Note that in this study, there was almost no delay between the action of the participant and the action-effect seen on the screen, whereas real-life mimicry effects typically have delays from 600msec to 6 seconds. A strong version of the universal predictability model should suggest that shorter delays are always more predictable and thus are 'better', but, as we will lay out below, it is not clear that this is the case for mimicry effects.

Predictability accounts of mimicry can also be extended to the case of shared preferences. Several models of social decision making have argued that the drive to affiliate with similar others can be linked to more fluent cognitive processing. For example, the anchoring and adjustment account of social inference argues that we use the self as a basis for inferences about the preferences of others leading it to take longer to process discrepancies between our own preferences and those of similar others (Tamir & Mitchell, 2013). Srivastava & Schrater (2011) designed a computational model of decision making in which cognitive agents naturally tend to affiliate and interact with other agents who share their "beliefs" due to the fact these agents are the easiest to predict the actions of and therefore cooperate with. Behavioural economic research has found that dyads whose members shared preferences ended up producing more optimal outcomes when playing economic games, even when the game required the dyad members to make different decisions. This provides evidence that participants have a real-world advantage when coordinating with others who they perceive as similar to them (Chierchia & Coricelli, 2015). These results show the potential for domain general processes based in cognitive fluency to result in an increased drive to affiliate with others who share one's preferences.

4.4. Distinguishing between models - awareness and timing

To potentially distinguish between these models and move the field of BeMim research forward, we suggest it is important to consider two subtle factors that could impact on people's experiences of being mimicked and their response to this. These factors interact and have rarely been studied systematically but have the potential to substantially affect our understanding of where BeMim effects come from and what they mean. First, we consider the case of awareness of being mimicked, and how that may rapidly reverse the positive, prosocial effects of BeMim. Second, we consider the impact of different time delays between the actions of a participant and the mimicker, and how this could link to both awareness and fluency effects. Third, we consider a few additional mediators such as the design of the control condition and the form of the agent's response to the mimicked person.

4.4.1. Awareness of being mimicked

In classic studies of BeMim effects in live interaction, there is an assumption (not always tested), that mimicry is an implicit effect. That is, the participants in the study are not aware that mimicry is the topic of investigation and are not aware that a confederate was mimicking their actions. In many studies, this is confirmed with a funnel-debrief interview after the main experimental task (Lakin & Chartrand, 2003; van Baaren et al., 2003), and it is common to exclude participants who guessed the goal of the study and/or realised that they were imitated. This choice by the experimenters is based on the intuition that participants would find being explicitly imitated to be a negative experience. Mimicry of (for example) political figures is a common form of mockery in popular entertainment (Filani, 2016), while in horror movies, excessive copying of a character's actions or choices is provided as evidence of ill intent (e.g., *Single White Female* movie (Schroeder, 1992)). However, we are aware of only one study which specifically tested the negative effects of awareness of motor BeMim.

Kulesza's team ran a study exploring the link between mimicry, awareness, and liking (Kulesza et al., 2016). University students were invited to the lab where they talked to a confederate who was introduced as an intern interviewer. The mimicry awareness was manipulated by the course description which students were supposed to read before the interview. There were 4 different conditions: participants did not get the module description (no awareness), they read general information about the mimicry (saying only that people mimic each other) or more developed information including either true (mimicking causes affiliation) or false (mimicking causes dislike) information about social consequences of being imitated. Then, participants were asked to share their thoughts about current university modules and the 'potential new course' (the course information provided before the interview was the awareness manipulation). During the interview, the confederate mimicked or not the posture and gestures of the participant. The researchers found out that when participants were not aware of mimicry or were told general information without mentioning its consequences, they liked their mimicking interlocutor more in the mimicry condition. However, when they were informed about the social consequences of being imitated (either true or false), mimicry did not influence rapport. In addition, in the non-mimicry condition, being aware of the true or false effects of being imitated increased liking.

These examples of negative feelings and changes in liking with awareness of BeMim, suggest that being mimicked and knowing about it might make participants feel they have been deceived in their social interaction. According to deception theories, advantages are lost when the deception is detected (Zuckerman et al., 1981). When a mimicked participant knows about the imitation, they can interpret it as a manipulation by the mimicker who might be trying to take advantage of them. An alternative explanation of why mimicry awareness reduces the liking effect of BeMim was introduced by Kulesza's and colleagues (2016), They suggest that it might be explained by a boomerang effect or reactance – participants' freedom was threatened by the expectation that they would like their interlocutor more, so they prevented this and did not pay attention to the copying behaviour. However, none of the participants reported being aware of the manipulation. It seems mimicry knowledge might not be the same as mimicry awareness. Would it change results if participants were aware of being imitated instead of having information about the manipulation in general? This is still unknown, and more research is needed.

As is the case with motor mimicry, very few studies have sought to directly examine the effect of awareness of BeMim for preferences. However, the limited studies suggest that people perceive deliberate copying as a negative act. We found two studies that directly investigated this question. The first study investigated the developmental trajectory of this dislike of being copied and found that adults and children as young as 5-6 years old disliked those who deliberately copied them when drawing, but that this was not the case for 3–4-year-olds (Olson & Shaw, 2011).

The second study by White & Argo (2011) examined how preferences for products were affected by deliberate copying. They found that participants were likely to want to dispose of or exchange a product, e.g., perfume if someone they knew deliberately copied them in using it. This was particularly the case if the mimicker was similar to the participant, if the product had high symbolic value, or if the participant had a high need for uniqueness or had been given an independent self-construal. Interestingly a recent study from D'Angelo and colleagues (2019) suggests that people are also aware of this dislike of obvious BeMim when they are in the role of potential mimicker. In D'Angelo's study participants were shown examples of customised products created by individuals in their social circle and then asked to make their own custom version of the product. They found that participants tended to design their own version of the product to be less similar to that of others, particularly when that other was a close friend.

The role of social closeness in motivating both the negative reaction from targets of BeMim (White & Argo, 2011) and the avoidance of copying in potential mimickers (D'Angelo et al., 2019) suggests that these responses are, at least to some extent, driven by a need to distinguish oneself from similar others. Such an account fits in with the claims of optimal distinctiveness theory (Brewer, 1991; Leonardelli et al., 2010), which posits that we seek to balance a need to be included with the need for distinctiveness. This theory can thus explain why people are particularly averse to BeMim from close others where distinctiveness is already low. This optimal distinctiveness account may also explain the negative response to others we see as infringing on our uniqueness via deliberate motor or preference mimicry. While there are not many studies which have explored the impact of awareness on BeMim effects, the fact that some impact can be found argues for models which can incorporate awareness effects. That is, social learning models and dedicated BeMim models could both include awareness effects without changing the core model. For example, if social learning mechanisms lead people to like those who mimic them but also to dislike those who are too close, this is compatible with data on awareness of BeMim. However, a domain-general predictability model might struggle to account for the impact of awareness on BeMim, because there is no obvious reason why awareness would change the impact of predictability across all domains.

4.4.2. Timing of being mimicked

The factor of timing in BeMim interactions is critically important for several reasons, and this can best be illustrated by considering some examples (illustrated in Figure 3). First, we can consider the classic real-world motor mimicry situation where a participant performs an action, and this is imitated by a confederate after a suitable delay. This condition is likely to lead to the strongest affiliative effects (Fig3B). However, if the delay were substantially longer, for example the confederate imitated after 5 minutes, it seems unlikely that this action would impact much on the participant and it might not even register as mimicry. In contrast, if the confederate imitated very rapidly, the participant is more likely to explicitly detect 'he is copying me' and the negative effects of being imitated might arise. A small number of studies have manipulated the timing of BeMim effects in different ways and can help us clarify when the positive and negative consequences arise.

In a set of pilot studies which explored different mimicry delay options, Bailenson et al. (2004) had participants sit in a virtual room with two agents: a human one whose movements were controlled by a person in another room and a computer-generated agent who was mimicking participants' head movements either at 1,2,4, or 8 seconds' delay. Participants were told that one agent is a computer and is mimicking their head moves and their task was to identify a human agent. On average, only 60% of participants correctly guessed which avatar is a real person. Moreover, it was easy for them to identify the mimicker when the delay lasted 1 second, and then the longer the delay, the more difficult it was for them to identify the mimicker. These results suggest that the shorter the mimicry delay, the easier it would be for people to detect the imitation.

A few years later, the same authors carried out a similar study where (among other goals) they examined the effect of mimicry detection on social influence (Bailenson et al., 2008). 11% of the sample detected head mimicry. In general, they found out that the mimicking agent was seen as more effective when participants did not realise that they were mimicked. When they detected mimicry, the agent was still evaluated well on the informativeness and agreement scale (more objective measures) but got a worse rating in terms of trustworthiness and warmth factors. The authors argue that the mimicking agent is seen as a liar by people detecting mimicry. As a result, participants give low ratings for warmth and credibility.

Using a similar method, Hale and Hamilton (2016) created a virtual human who carried out a picture-description task with a naive participant. The virtual human imitated the participant's head movements with either a 1 second delay or a 3 second delay (between subjects). 30% of participants from the 1-second delay group detected the mimicry manipulation but only 4% of participants from the 3-second delay group detected it (Hale and Hamilton, 2016). In a follow-up, Hale & Ward captured head nodding motion from natural conversation and suggested that delays of only 600msec are most common in real interactions (Hale et al., 2020). This is substantially shorter than used in most studies with artificial agents. A study with artificial agents used the natural BeMim delay of 600 msec in a picture description task and found that agents who showed this behaviour were rated more positively than those who did not (Aburumman et al., 2022). An important new study examined the effects of timing in detail for facial expressions (Kroczek & Mühlberger, 2023). Participants were instructed to produce a smile or frown and then saw a smile or frown from a virtual agent and were asked to rate if the agent 'was responding to me'. Critically, facial EMG recordings from the participants were used to precisely calculate the delay between the participant's action and the agent's action on each trial. Results showed a clear non-monotonic effect, with peak ratings of 'responsiveness' around 600-700 msec for both smiles and frowns; actions that occurred faster or slower than this time were rated as much less responsive. While this is not a direct measure of BeMim effects, the study does provide striking evidence that the timing of social behaviour matters and that 600-700 msec may be an optimal time delay for perceiving interactivity.

Based on the results summarised above, the optimal timing for BeMim effects is still unclear. While some studies suggest delays should be as long as 3-7 seconds, others have found positive effects with delays as short as 600 msec. It is clear that short delays can also lead to more detection of BeMim, leading to the negative effects described above. This is hard to reconcile with a fluency/predictability model of BeMim, because under that model, movements with short delays should always be easier to predict and thus be more positive. In contrast, the conjunction of the timing and awareness studies suggest that predictability is not the only thing that matters for BeMim effects. Instead, BeMim may work best in a 'sweet spot' that is similar but not too similar, in a pattern reminiscent of optimal distinctiveness effects.

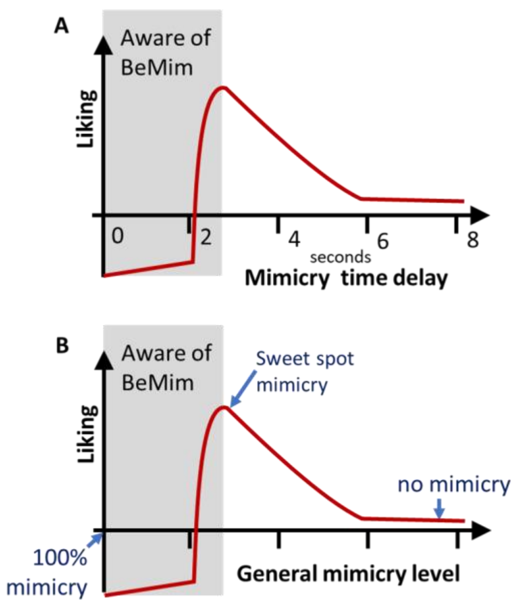

Figure 3. Hypothesised mimicry effects. ***A****. The effects of time-delays on motor mimicry. As delays become shorter (from 6 seconds to 3 seconds), motor mimicry has a positive effect on liking, but if the mimicry is detected (grey box), then participants may dislike the person mimicking them.* ***B.*** *In the case of abstract mimicry, the parameter 'time delay' could be replaced with a more general 'mimicry level' parameter. Perfect mimicry could be detected and disliked, whereas the mimicry at the 'sweet spot' level would lead to liking. This is similar to the idea of optimal distinctiveness.*

However, the results described above for timing apply primarily to motor mimicry where each action is a distinct event that occurs at one time. In contrast, a preference normally lasts over a longer time (the painting I prefer on Monday will still be preferred on Tuesday), so it may not make sense to study mimicry timing in the context of shared preferences. It remains to be seen if there are other factors which behave in the same fashion as timing in the context of abstract mimicry - perhaps just the intensity of the mimicry matters. For example, copying one element of a complex item might be positive but copying all elements might be negative.

These results showing that both awareness and timing of BeMim can modulate its social effects help to give us some means of evaluating the three different models that we discussed above. As previously mentioned, studies showing that there is an optimal time frame for motor BeMim that is not directly linked to the predictability or fluency of response is a point against our Model 3 account which attributes the positive effects of BeMim purely to domain general fluency effects (Bailenson et al., 2004; Hale and Hamilton, 2016). In addition, findings suggesting a similar negative response to the detection of BeMim in both the motor and preference domains give some support to the Model 2 accounts that relate BeMims effects to a social but not motor specific, set of neurocognitive processes such as the desire for optimal distinctiveness or the detection of attempts to deceive or manipulate (Brewer, 1991; Bailenson et al., 2008).

5. Summary

To sum up, in the first part of this chapter we presented an overview of BeMim methods. There are numerous approaches to study BeMim effects - researchers can choose from a spectrum of real-world (ecological, but not controlling cofounds) and controlled in the lab (less interactive but removing cofounds) paradigms. In general, using a wide range of methods is useful - it allows researchers to combine benefits of various approaches (e.g., adding more control to a live study paradigm using VR agents designed to perform with specific timing instead of human confederates). The choice is also to be made between motor movement and abstract preferences mimicry. However, it is still unknown whether various BeMim paradigms tap the same cognitive mechanisms. More carefully designed studies that bridge across methods will be needed to determine this, possibly including real-world neuroimaging methods.

The second part of this chapter covered cognitive mechanisms for processing BeMim. There are three possible main neurocognitive models which try to explain how BeMim could work: a specialised mechanism for BeMim, universal predictability, and social learning model. The first one labels mirror neuron systems (MNS) as a specialised cognitive mechanism that responds to performing an action and then seeing others doing the same action. The universal predictability is about more general, non-social mechanisms responding to BeMim: fluent or predictable events are easier to process and potentially more enjoyable than disfluent or unpredictable events. The social learning model claims that there is a general human social learning mechanism responsible for learning about others and having a preference for people similar to them, which applies to both motor mimicry and abstract preference sharing but not to non-human objects. In the last part of the chapter, we discussed awareness and timing of BeMim. The impacts of BeMim on social judgement and social affiliation are probably non-monotonic. That is, more mimicry is not always better. Both the awareness studies and the timing studies suggest that mimicry which is too close in time and space and form to the participant's action is judged negatively rather than positively.

Based on these ideas about awareness and timing, we suggest that the social learning model seems to be the strongest one. This is because data suggest that people prefer to be optimally distinctive to others, both in their abstract choices and their motor patterns, and this fits best with the social learning approach. Gaining a greater understanding of the links and parallels between BeMim for motor tasks and BeMim for abstract tasks will be useful to advance our theories in this area.

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