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Play Without Regret.

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When imitation falls short: The case of complementary actions

Imitation is seen by many researchers as the driving force of human evolution and as a primary factor controlling the development of culture (Legare & Nielsen, 2015). Imitation allows you to learn to ride a bike and to stay in line at the supermarket but it also affects your choice of clothing and can even determine what type of work you do. Imitation, or copying behavior displayed by others, might look simple at first glance but is in fact quite complex. One precondition for imitation is that you have to learn that what others do is similar to what you yourself are doing or are able to do (e.g., seeing a person's right hand move – moving your own right hand). Specifically in the first few years of infancy this is problematic. When you see behavior displayed by somebody else (e.g., your mother smiling at you), you will see this behavior from a flipped perspective (as displayed by the mother) and you will only see the visual effects of the displayed behavior. At the same time, producing behavior yourself (e.g., smiling; moving your hand), is determined by a motor command which directs muscle movements that subsequently provide visual feedback from a first person perspective (or no feedback at all). This discrepancy provides the following question: How do you know what muscles to use if you only observe the visual effects of behavior performed by others, seen from a mirror perspective? This problem is called the *correspondence problem*. What complicates this even more is that until a certain age infants are not able to self-identify or take the perspective of others. But even under these conditions infants are able to show imitative behavior from an early age.

There is an ongoing debate about the mechanisms that solves the correspondence problem which is strongly connected to the nature-nurture debate. Where some researchers argue that people are born with a module that 'translates' observed behavior into the production of the same behavior (Meltzoff, 1988), a different group of researchers argues that people are born with a general purpose mechanism that can produce imitation as well as different types of behavior as a consequence of associative learning processes (Heyes, 2016). These learning processes are based on a simple rule that specifies that repeated co-occurrence of observed and performed behavior creates associative links. Recent empirical research and a re-analysis of 20 years of baby research support the latter view and shows that there is no strong evidence for an inborn module that facilitates matching (imitative) connections. The findings do support the idea that baby's learn by being imitated by others (e.g., parents), by looking in the mirror or by observing their own hands while moving them. These experiences create associative links between neural regions that code the visual effects of behavior and regions involved in motor control which can stimulate imitative behavior over time. For example, if for every time a baby smiles, a parent smiles back, the baby will over time associate the production of a smile to the observation of a smile (e.g., seeing the corners of the mouth move upwards) which accordingly can produce imitative behavior. The intensity and frequency of these experiences strengthen associative connections. For example, you can feel that you move along when observing a ballet performance if you are a ballet-dancer yourself or as a basketball player watching a basketball game but maybe to a lesser degree when observing a ballet performance as a basketball player.

Even though imitation is important in a lot of situations, it is primarily a passive process. More importantly, imitation is in the majority of social situations not a fitting type of behavior. For example, when someone throws a ball you catch it, if somebody pours you a drink you bring your glass forward, when somebody cries, comforting him or her is a more fitting type of response. The beauty of associative learning processes is that this type of behavior (complementary actions) is learned using the same mechanism that produces imitation. Because neural modules involved in shaping associative links are not specifically designed for imitation, linking behavior that is either congruent (similar) to observed behavior (imitation) or incongruent to observed behavior (complementary actions) can be a result of the same learning process. Even though the repeated coupling of seeing a laughing mother when a baby smiles constitute a congruent association (imitation), there are a multitude of situations in which people learn incongruent associations (e.g., throwing a ball – catching it). Nonetheless, research within (social) psychology is dominated by imitation and specifically the automatic coupling between observing and performing congruent (identical) behavior.

In the current dissertation we have looked at the distinction between imitation and complementary actions and we argue that in a host of situations imitation is not a product of repeated learning and is not functional in predominantly social (interactive) settings. The first step was to use classic studies in the field and to look at the boundary effects of imitation behavior within each study. An example is a line of research that has shown how pictures of stereotypical groups trigger associative behavior related to this group (e.g., criminal – aggressive behavior). The first chapter builds on this example and describes two studies in which we used a task where participants saw pictures of different stereotypical situations (dark alley, court room), followed by a word representing a social category member (criminal) that was associated with the situation. Subsequently, we showed pictures of objects associated with the social category that had different functions depending on the situation. For example, a gun is associated with a criminal but has different functions in a court room compared to a dark alley. Our question was whether participants would pay attention to objects only if the object was seen as fitting given the situation and social category. Alternatively, participants would primarily be driven by the association between the social category and the object irrespective of the situation. During the task we used gaze-tracking to track the amount of attention devoted to each of the objects. The results showed that participants indeed paid more attention to objects associated with the social category but differently so depending on the situation (dark alley – criminal – gun). This suggests that when people do not have any situational information to start with, they might be driven by behavior displayed by others but when they do have this information they pay attention to objects that are useful as a means of response in that specific situation.

In the first chapter visual attention was the main dependent variable. We were also interested in physical, overt behavior to reach a better understanding of the boundaries of overt imitation. In the second chapter we used a computer task in which participants saw a series of pictures of a person extending either his right or left hand. This hand was either a closed hand (fist) or an open hand movement. The person extending his hand was either sitting close by, across from the short side of a table, or far away, across from the far side of a table. Depending on the color of the hand (this was green in fifty percent of the images), participants had to copy the exact hand movement in the image in mirror perspective (e.g., seeing a right closed hand and making a left closed hand movement) or using their opposite hand. The idea was that when seeing an open hand movement, people would automatically feel the urge to use their opposite (complementary) hand instead of their hand in mirror perspective. However, because you can only shake somebody’s hand if this person is within reach, this effect was not expected if the person was out of reach. By measuring how long it takes to produce a hand movement, we could see if participants were faster when making an open hand movement or a closed movement and if they were faster if the person on the screen was sitting close by or out of reach. We ran five studies that consistently showed no effect of distance. We did find that participants were faster in making a complementary (opposite) hand movement compared to performing a hand movement in mirror image only when an open hand movement was observed. For closed hand movements this effect flipped, participants were faster performing a hand movement in mirror image compared to using their opposite hand, indicating an imitation effect. This set of studies shows that complementary actions are performed automatically, similar to earlier studies looking at imitation behavior. Contrary to the first chapter it seems that this automaticity is so strong that it is not affected by perceived distance. This might explain why you can have the feeling to be part of a sports game while watching television or when playing a computer game, without being physically there.

The third chapter concerns the role of perspective taking in imitation as explained in the first part of this summary. Imitation is often coupled to perspective taking because copying someone's behavior is linked to being able to judge how it 'feels' to perform behavior from that person's perspective. As argued before, imitation is primarily used in passive situations. However, when interacting with others and when performing complementary actions, taking your own perspective (first person perspective) is more important. For example, you have to know how to catch a ball from your own perspective, taking the perspective of the thrower will be less relevant. Nonetheless, a set of studies has shown that perspective taking is important specifically when behavior displayed by others is important or relevant to you. This makes sense, it would be tiring to constantly compute the perspective of those around you or to involuntary imitate everyone you see. To make this point, however, researchers often have used passive instead of active social situations. In the third chapter we discuss three studies each using the same task, in which we added an active rather than passive social scene. Participants observed pictures of a person on a computer screen in front of whom two objects were displayed (a book and a glass) on a table. Subsequently, participants had to indicate where the book was positioned with respect to the glass. From your own perspective this could be left but when taking the perspective of the person in the image this would be the opposite (right). By making small changes to the scene, we could transform a passive scene, where a person was looking straight forward without touching any of the objects, to an interactive scene where the person grasped one of the objects and held it straight forward (towards the screen). In three studies we looked at the time it took for participants to judge the correct location of the objects and how often they took the perspective of the person in the image depending on the type of scene. We hypothesized that contrary to the idea that interactive scenes would lead to increased perspective taking, they would actually inhibit perspective taking because these scenes typically require taking a first-person perspective. This means that if participants were asked to take the perspective of the person in the image in an interactive scene, this would lead to more errors and longer response times (it would take longer to choose the correct location) compared to more passive scenes when judging the object's location. Two of the three studies supported this hypothesis, although it seemed that perspective taking in interactive settings was more difficult irrespective of the participant's task to take the perspective of the person in the picture or their own.

The final chapter takes a different approach to the first three in that it looks at what happens in the brain when observing behavior that can lead to imitation. By repeatedly observing behavior displayed by others just after or before performing behavior yourself, this facilitates automatic imitation or complementary behavior. On a neural level, this means that when simply observing specific behavior this activates the same motor regions that are involved when performing the behavior yourself. A number of experiments suggest that specific neurons, so called mirror neurons, facilitate this mechanism. A consequence of the repeated coupling of visual information and overt behavior is that over time this association becomes a predictive one. If you have sufficient information about what is going to happen in the near future, it is possible to simulate behavior before you actually observe it. For example, if you are at the zoo, you are more relaxed when walking past the tiger cage compared to being on a safari. Environmental information helps you with predicting upcoming events and this can be measured on a neural level in motor regions before any event has taken place. The fourth chapter describes a study in which we used EEG (electroencephalogram) to observe changes in motor regions in the brain when observing simple hand movements. Participants were shown short clips which were predictable to a varying degree. Depending on the color of the hand at the start of the clip participants could predict if they would see a precision movement (using a thumb and index finger) towards an object or a whole hand grasp. For some of the colors, the hand movement was highly predictable (e.g., 70 % of the trials they would see a precision movement) but for other colors the hand movement was not predictable (50 % precision, 50 % whole hand). We expected that participants would simulate the hand movement before any movement would take place but only when they were very sure about the outcome. Also, we expected that movements that could not be predicted would lead to stronger involved of motor regions but only during the observation of the movement. Using time-frequency analysis, where we looked at the extent to which clusters of neurons fire in synchrony, we compared clips that were highly predictable with those that were not predictable. The results showed that motor regions in the brain were more active when participants anticipated a highly predictable movement compared to anticipating a not predictable movement prior to the onset of the movement. While observing the hand movement, there was no difference in neural involvement between highly and not predictable movements. However, we were able to distinguish instances were highly predictable movements were followed by a predicted and an unpredicted movement. Also, observing an unpredicted movement was different from observing a not predictable movement, which suggests that participants were probably not guessing the specific movement before observing it.

The findings in this dissertation have shown a number of things: a) contextual information determines the visual attention for objects relevant for complementary behavior; b) complementary actions can be performed automatically, similar to imitative actions, and is independent of interpersonal distance; c) interactive settings inhibit perspective taking, and d) motor processes have predictive processes that helps people to anticipate other’s actions. Even though the findings provide mixed evidence and are not fully coherent with regards to the main question, they go against a model in which observing behavior automatically triggers (covert or overt) behavior. Depending on contextual information, the degree to which behavior is displayed by others in a passive or active manner and the degree to which behavior is predictable, complementary behavior is often more fitting than imitative behavior. This has consequences for a number of theories that limit themselves to the coupling between the observation and automatic performance of similar behavior. Also, our findings have consequences for the role of mirror neurons which by some have been described as means of facilitating imitation and even empathy. Similar findings in the field have shown how mirror neurons respond to a broad array of behaviors, also when the behavior has no specific goal.

Researchers from different labs that have looked at the same processes have shown comparable findings to ours and have demonstrated how imitative and complementary actions are used interchangeable in interactive situations. This dissertation has (hopefully) contributed in part to this effort.