## The stuff formally known as the reply against spatial coding

Before co-representation can occur there must be some sense in which Ayesha and Beatrice perform the task together. They must be performing their respective parts as parts of a joint action rather than performing merely co-occurring individual actions. That is, there must be present a representation of the form, *I am directing guests to the groom’s side as part of us (Ayesha and Beatrice) directing guests.*

Empirical studies have found evidence that a sense of shared agency is a precondition for co-representation in several studies that have shown that the belief that one is co-acting, and further the belief that one is co-acting with an intentional agent, modulates co-representation effects found in the joint Simon task. For example, Tsai et al. (2008) conducted a version of the joint Simon task in which participants believed they were co-acting with a hidden human co-actor or a computer. In both cases, the part of the co-actor was played by a computer, so the only thing that differed was whether the participant conceived of themselves as co-acting with an intentional agent or a non-intentional machine. The results showed that only when participants believed that they were co-acting with a human did the spatial compatibility effect emerge. When participants believed they were co-acting with a computer the results mirrored the pattern of data found in the individual go/no-go task. Similarly, Guagonano et al. (2010) found that when two participants sat side-by-side performing two independent tasks, a spatial response-compatibility was only found when the two participants were in very close physical proximity, and this effect was absent when the two participants moved outside of peri-personal space. The emerge of the effect when the two participants were in close physical proximity is likely due to the other individual acting as a spatial reference for coding the participants non-spatial responses. That is, participants responses might be coded as LEFT simply because there is a salient environmental features—another person—to their right (see also, Dolk et al., 2011) [[1]](#footnote-1). However, when the participants moved out of peri-personal space this spatial reference is removed and, therefore, unlike the results of Tsai et al., where participants were engaged in a joint action, the spatial-response compatibility effect disappears without a co-representation to support it.

Similar findings to Tsai et al. (2008) have also been reported by Stenzel et al. (2012). However, in the case of Stenzel et al., participants performed the task with a robot co-actor that was always presented and they were then given different beliefs about how the co-actors actions were controlled. In the *human-like* condition, participants were told that the robot had been designed to function in a biologically inspired manner, while in the *machine-like* condition participants were told that the robot operated in a purely deterministic manner. That is, in the human-like condition participants were encouraged to attribute human-like intentions and decision processes to the robot. A debriefing questionnaire, in which participants were required to indicate their agreement with phrases such as “The robot acted intentionally” and “The robot decided actively when to respond to a stimulus”, confirmed that this manipulation did indeed have the desired effect. The results showed that only under the *human-like* instructions did the spatial response compatibility effects emerge. This is to be expected if co-representation only occurred only when the co-actor was capable of acting according to intentions (or at least when one adopts an intentional stance toward the co-actor).

The importance of holding the belief that one is co-acting is further underscored by findings from Welsh et al. (2007) and Vlainic et al (2010). Welsh et al. found that the joint Simon effect disappeared after the confederate left the room while Vlainic et al. found that the Simon effect remained even when co-actor was hidden. Vlainic et al. suggest that the key difference between their paradigm and the paradigm employed by Welsh et al. is that they continually reinforced the participant’s belief that they were co-acting with another agent. Thus, they argue, Welsh et al.’s failure to find the spatial compatibility effect in the hidden co-actor condition is due to participants not holding a sufficiently strong belief that they were jointly performing a task.

## The stuff about the GROOP effect and joint tasks

In addition to task representations, and task co-representations, where agents represent their part of a task, it is also possible to represent the task as a joint task. For example, in addition to the representations of the form *I am directing guests to the groom’s side as part of us (Ayesha and Beatrice) directing guests*, a representation of the form *we are directing guests* might also be present. These are representations of the joint task; representations that make reference to *we* rather than *me* or *you.*

What is the evidence for the existence of joint task co-representation? One of line of evidence comes from automatic imitation tasks, which can be used to support the existence of task co-representation and have been extended to provide support for the existence of joint task co-representation. In the original automatic imitation describes the phenomenon whereby people are quicker to produce an action in response to a stimulus when that stimulus shows the to-be-produced action. For example, Brass et al. (2000) found that when participants were presented with a stimulus that contained a response relevant stimulus dimension (a number) along with a response irrelevant stimulus dimension (a raised finger), participants were quicker to make a response to the number when the response required raising the same finger as in the stimulus display.

Importantly, it is not simple action matching that drives the effect, but rather match between the task goals of the participant and the task goals of actor depicted in the display. For example, Liepelt et al. (2008) found that automatic imitation effects could be extinguished when the participant s and the observed actor has different task goals. In this study, participants were asked again asked to raise their finger in response to a number cue while ignoring the finger that was raised in the display. They performed this task under two conditions where they were either instructed that the actor in the display was trying to fully raise their finger (therefore matching the participants task goal) or that the actor was only try to partially raise their finger (therefore not matching the participants task goal). Critically, the actor in display has their finger enclosed in a restraint that prevented them from fully raising their finger thereby keeping the actually observed action identical in both conditions. The results showed that only when the participant and the observed actor had the same set of task goals (that of fully raising their finger) were responses facilitated when the displays contained the same action that the participant was required to make. When the participant and the actor had a different set of goals, no facilitation was observed. [[2]](#footnote-2)

One way to account for this finding is through co-representations of task. If in addition to representing their own task goals, participant also represented the task goals of the observed actor. The observation of the action would then partially activate the equivalent goal representation in the observer and thereby facilitate the production of the subsequent action linked to that goal.

What is important in the automatic imitation paradigm is that the effects are driven by participants representing their tasks goals in the form *me raise middle finger* or *me raise index finger*. However, as mentioned earlier, it might be possible for pairs or groups of co-acting individuals to represent their task jointly in the form of representations that make reference to *we*. Tsai et al. (2011) ran a series of experiments to examine whether *we-*task, or joint task, representations could modulate the effects found in automatic imitations tasks. To do, they modified the task so that a participant acting with a confederate viewed two hands. The participant’s task was to perform a key press with their right hand in response to a key press performed by ipsilateral hand in the display, and to withhold their response when the ipsilateral hand did not move (go/no-go task). The hands on screen could either move in isolation (one hand at a time) or both hands (both the ipsilateral and contralateral hand) could move.

The congruency between the number of people observed in the display and the number of people responding could then be manipulated. In the group observed condition, the two observers (participant and confederate) observed two hands belonging to two individuals[[3]](#footnote-3) (that is, a group viewed a group’s movements). While in the individual observed condition, the two observers observed the left and a right hand belonging to a single individual (that is, a group viewed an individual’s movements).

Numerical compatibility was also manipulated by varying the confederate’s task. In the numerically compatible condition, the participant and the confederate simply responded to movements on their side. Therefore, when a single movement occurred either the participant or the confederate responded—a “me” response—while movements on both sides required a response from both observers—a “we” response. In the numerically incompatible condition, confederates responded to hand movements on either side of the display, but withheld their responses when movements occurred on both sides. Therefore, a single movement on the participant’s side required a response from both the participant and the confederate—a “we” response—while a movement on both sides only required a response from the participant—a “me” response. Importantly, the task for the participant was always to respond to movements on their own side. What was varied was the relation between the participant’s responses and the responses produced by the confederate. If participants do indeed form *we-task* representations would predict during this task then we can expect to see an effect of numerical compatibility on response facilitation. That is, when the participants are acting as a group their responses should be facilitated when they also observe group acting.

The results confirmed this prediction. When observing a group, participants responded faster to movement of two hands when the confederate was also required to make a response—a “we” response—relative to the case where the participant produced a response alone—a “me” response. Furthermore, participants responded quicker to movements of one hand when the only they were required to respond, and the confederate withheld their response, relative to the case where they were both required to respond. In addition, analyses showed that when observing the movements of a single individual—that is, an agent that can only perform “me” movements—the nature of the confederate’s task had no effect on speed of responding. Simply put, when observing group movements, participant’s responses were facilitated on trials where there was a match between the number of actors moving in the display and the number of actors responding. That is, “we” movements were facilitated by observing “we” movements and “me” movements were facilitated by observing “me” movements. Importantly, on all the trials the participants task remained the same, what differed was only whether they considered themselves as acting individually or as part of a group. This pattern of data can be explained by the existence of joint task representation—that is, representations of tasks as being joint tasks. As with Liepelt et al. (2008), only when there is a match between the task of the observer and observed agent are responses facilitated; however, in the experiments of Tsai et al. (2011) it is not a match between the two tasks conceived of as tasks to move a finger in particular way but a match between whether the two tasks are conceived of as joint or individual tasks.

1. The observation that participant’s responses can be coded as LEFT or RIGHT by the mere presence of another individual seated in close proximity to the participant has been used to argue that co-representation effects found in the joint Simon task literature can instead by explained by this lower level spatial coding mechanisms. However, the evidence does not seem to support this claim a some studies, such a robot co-actor experiment (Stenzel et al., 2012) described below, cannot be easily reconciled with this account. In this study, the spatial reference provided by the presence of the robot co-actor remains unchanged with the modulation of the joint Simon effect being totally reliant on the beliefs held by the participant. [↑](#footnote-ref-1)
2. A follow-up study by Liepelt and Brass (2010) found that response facilitation could also be extinguished when the observed actor was a non-intentional agent (a puppet) and in therefore incapable of possessing task goals. [↑](#footnote-ref-2)
3. In Experiment 1 observes viewed a two right hands belonging to two individuals while in Experiment 2 observed viewed a left and a right hand belonging to two individuals. This was found to have no effect on the pattern of data observed. [↑](#footnote-ref-3)