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1 What It Takes to Share a Task: Sharing versus Shaping Task Representations

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Abstract

In this chapter, we examine task representations in shared task settings like the joint ('social') Simon task. Over the past decade, ideas pertaining to shared representations and co-representation have been advanced to account for performance in such settings. Here, we argue that we can do without these notions. On the one hand, we show that shared representations cannot account for typical findings in shared task settings. This is the negative part. On the other hand, we show that task performance can be explained by the claim that individuals shape their individual task representations according to the needs of the shared task. This is the positive part. Consequentially, we claim that performance in shared task settings relies on shaping individual representations, not sharing common representations. To get there, we take three major steps. First, we examine what it takes to share a task and what the notion of task co-representation entails. Second, we discuss the joint Simon task and the joint Simon effect. Here, we show that the explanation of the effect in terms of shared representations does not work. Instead, we suggest an explanation in terms of referential coding. Finally, in a third step, we come back to the role that social modulators may play in the framework of referential coding.

Task Sharing

Shared Representations

Let us first see what the broad notion of shared representations entails. When do we speak of shared representations and what are they supposed to be good for? To start with, when do we speak of representations at all? Broadly speaking, we invoke representations as hypothetical entities operating in cognitive systems. Their unobservable operation is meant to account for observable segments of (first-person) experience or (third-person) performance. Accordingly, representations are intrinsically individual and private. They can only arise and operate in individual minds, and there is no obvious way in which they could be shared with other minds (Prinz, 2012).

Thus, when we talk about shared representations we do not mean to say that two (or more) individuals share one and the same representation. Instead, what we mean to say is that two or more individuals entertain private representations that refer to one and the same reference object or event. This way they can be both private, i.e. existing in individual minds, and shared, i.e. referring to the same reference. Shared representations may be seen to underlie both shared experience and shared performance. We speak of shared experience when two or more individuals perceive, remember, think, believe or desire certain things and when they do so on the understanding that other individuals do so as well. Likewise, we may speak of shared performance when an individual performs a given task in collaboration and coordination with others. In both cases, we may claim that experience and performance are grounded in shared representations, i.e. representations referring to the same common thoughts, beliefs or desires and the same common task in which the individuals are involved.

The idea that representations can be shared in this way is fundamental for understanding social interaction (Clark, 1996; Tomasello, 2009; Tomasello, Carpenter, Call, Behne, & Moll, 2005). This pertains to both experience and performance. The notion of *shared experience* acknowledges the fact that we are social in the sense that we see the world not only through our own eyes but through others' eyes as well. Likewise, the notion of *shared performance* acknowledges the fact that we can easily collaborate and coordinate with others in many kinds of joint activities. The idea of shared representations thus appears to be a theoretical foundation stone for understanding social communication and interaction that we cannot dispense with (cf., for example, Echterhoff & Higgins, 2010; Higgins, 1981, 1992).

Shared Task Representations

Let us now see how the general notion of shared representations may apply to the special case of shared task settings. We speak of shared task settings when a task is distributed between two (or more) individuals in a division-of-labour mode. Typical examples include playing a piece of music together, carrying a table downstairs or performing the joint Simon task (see below). One of the crucial features of such scenarios is that the involved individuals share the common goal of achieving the task at hand.

It appears to be a natural idea to account for performance in such task settings in terms of shared representations. In order to successfully perform such tasks, individuals must control their own performance in a way that takes their partners' contributions into account. One way of fulfilling this requirement is to co-represent their task shares. If this happens, each participant will form a task representation that represents not only his/her *own share* of the task, but the other participants' *foreign shares* as well. Thus, as a result, each participant will eventually form a representation of the full task.

According to this view, individuals take foreign contributions to the task into account in terms of the way in which others represent their task shares. The notion of task co-representation thus instantiates the idea that individuals look at the task not only through their own eyes but through foreign eyes as well. A claim like this is in functional terms quite demanding. Can we come up with a weaker, less demanding claim? An obvious alternative is to think of others not in terms of their (unobservable) task representations, but rather in terms of the (observable) events that instantiate their performance in the task scenario. This view opens an entirely different perspective for taking foreign contributions into account: not in terms of *tasks* that others have in mind, but rather in terms of *events* through which their performance is instantiated. According to this view, individuals may be entirely ignorant about the others' tasks. Instead, what they share with them are representations of the common scenario of objects, events, actions and agents.

Some would perhaps argue that this can be considered a weaker form of co-representation: event co-representation rather than task co-representation (cf. Dolk et al., 2011). In fact, it is not always clear in the literature what the concept of co-representation is precisely meant to refer to. For instance, it has been suggested that co-representation may refer to actions or agents in the task scenario (e.g. Philipp & Prinz, 2010; Sebanz, Knoblich, & Prinz, 2003, 2005; Wenke et al., 2011). According to this broad reading, the term 'co-representation' would apply to any kind of representation of social facts. Yet, we do not think that broadening the concept this way makes any sense (for further support and discussion of related issues, also see Heyes, 2014). As discussed above, this concept is meant to capture the idea that individuals do not just represent things and events, but also co-represent the way in which others represent them. This is what the concept entails – and this is actually what constitutes the power to explain the emergence of interference in the joint setting.

By contrast, no such claim is entailed in the notion of event representation. When applied to shared task settings, this notion captures two basic ideas. At the descriptive level, it captures the trivial fact that shared task scenarios tend to be richer than regular, unshared scenarios of the same tasks. At the explanatory level, it captures the claim that the social facts that make up these enrichments (i.e. foreign agents, actions, and so on) are taken into account for forming and shaping individual task shares (i.e. the cognitive representation thereof) according to the needs of the task.

The Joint Simon Task

In this section, we examine the joint ('social') Simon effect (JSE) as a test case for studying the relative merits of the ideas of sharing and shaping task representations. As indicated above, the interference effect obtained in the joint Simon task has from the outset been associated with the notion of task co-representation (Sebanz & Knoblich, 2009; Sebanz, Knoblich, & Prinz, 2003; Welsh et al., 2013a, 2013b). In fact, this notion was originally created to account for this effect (Sebanz, Knoblich, & Prinz, 2005).

Findings

Basically, the joint Simon task can be described as a classical Simon task that is divided up between two participants. In the classical (two-choice) Simon task, single participants are required to select one of two keys in response to, for example, the colour of a stimulus patch (e.g. red or green). The patch may appear on the left- or the right-hand side of the screen. Colour is thus relevant for response selection, whereas location is irrelevant in the sense that it plays no role in response selection at all. Yet, on the other hand, the location of the key to be pressed (mounted on the left- versus right-hand side of the table) is a crucial distinctive feature between the two competing responses. The task can thus be seen to instantiate a conflict between two roles of the same feature: while stimulus location is entirely irrelevant, response location is highly relevant for response selection. The pronounced interference effect that is regularly observed in the two-choice Simon task (i.e. smaller RTs in trials with spatial stimulus–response correspondence as compared to trials with noncorrespondence (see, for example, Figure 1.1) indicates that participants in fact find it impossible to effectively ignore the location of the colour patch. The interference effect suggests that the irrelevant stimulus feature (location) is mandatorily processed. It looks as if the strong role that it plays for response selection somehow spills over into stimulus processing.

The joint Simon task combines two participants who are required to perform two independent, complementary *Go/NoGo* tasks. Typically, the two are seated next to each other, with one response key assigned to each of them. Instructions may require, for instance, that one responds to green but withholds from red stimuli and the other does the reverse. Each participant's share of the task is thus completely equivalent to a regular *Single Go/NoGo* task in which a single individual responds to one of the two colors. Accordingly, when looked at from an individual perspective, the *Joint Go/NoGo* task should exhibit the same pattern of interference as the *Single Go/NoGo* task. Surprisingly, however, this is not what the data show. Results from several studies have shown that the Simon effect 'goes away' in the *Single Go/NoGo* task, but 'comes back' in the

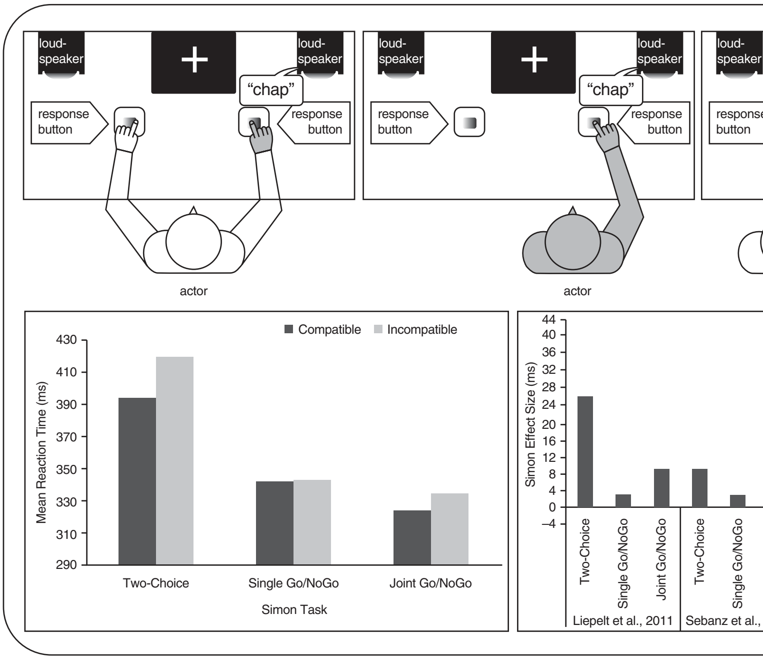

Figure 1.1 Three versions of the Simon task: *two-choice*, *Single Go/NoGo* and *J*

Notes: The lower row prototypically illustrates the result pattern typically obs
mean reaction time (RT; averaged based on the results of Liepelt et al., 2011;
a function of the Simon task (*two-choice*, *Single Go/NoGo*, *Joint Go/NoGo*)
(compatible, incompatible). On the right: Simon effect size (i.e. incompatible–
task version (*two-choice*, *Single Go/NoGo*, *Joint Go/NoGo*) for the study of L
(2003) and Vlainic et al. (2010), as well as the mean of all three studies (far rig

Joint Go/NoGo task (Liepelt, Wenke, Fischer, & Prinz, 2011; Sebanz et al., 2003; Vlainic, Liepelt, Colzato, Prinz, & Hommel, 2010). This finding has been taken to suggest a profound impact of social context on the mechanisms underlying the interference effect (Sebanz et al., 2005; Müller et al., 2011a, 2011b; Tsai & Brass, 2007; Welsh, 2009; Welsh et al., 2013).

Narratives

We may discern two narratives within these findings: *brief* and *extended*. The brief narrative has three major items: (i) the classical Simon task requires the actor to *choose* between two response alternatives. In this two-choice task, a substantial interference effect is obtained. (ii) The interference effect goes away when the *Choice* task is replaced by a *Go/NoGo* task. This task requires selective responses to one kind of stimulus, but no response to the other kind (*Single Go/NoGo*). (iii) The interference effect is back when the *Go/NoGo* task is performed jointly, i.e. when two individuals perform complementary selective responses (*Joint Go/NoGo*; Sebanz et al., 2003, 2005; Welsh, 2009; Welsh et al., 2013).

The brief narrative seems to suggest an obvious conclusion, viz., the *Joint Go/NoGo* task is in functional terms similar, if not equivalent, to the *Choice* task. Moving from description to explanation, it has been assumed that each participant co-represents, on top of his/her own share of the task, also his/her partner's complementary share – to the effect that the two eventually share representations of the full task (Sebanz et al., 2003, 2005; Sebanz & Knoblich, 2009). Since the full task combines two complementary *Go/NoGo* tasks, it exhibits precisely the same functional requirements as the *Choice* task. This elegant move explains why the interference effect is reinstated in the joint task. The idea of co-representation claims that social context leads participants to combine own and foreign task representations into an integrated and shared representation of the full task in an automatic and mandatory fashion (Sebanz & Knoblich, 2009; Welsh et al., 2013).

Yet, one may claim that the brief narrative, on which this interpretation relies, does not cover the full story and may therefore be misleading (Dolk et al., 2011). To cover the full story, it requires two important extensions. (iv) The first extension pertains to response speed: reaction times in the *Joint Go/NoGo* task are at about the same level as in the *Single Go/NoGo* task – far from the substantially higher reaction times in the *Choice* task (see Figure 1.1, lower left panel).

This observation speaks against the idea that the joint task is functionally similar, or even equivalent, to the *Choice* task. (v) The second extension pertains to the size of the interference effect: the Simon effect obtained in the joint task is always much smaller than the classical effect in the *Choice* task (i.e. two-choice Simon task typically > 25 ms; (single/joint) *Go/NoGo* typically ranges between 5 and 15 ms; see, for example, Figure 1.1 lower right panel). This observation speaks against the suggestive account that the original effect from the *Choice* task goes away in the *Single Go/NoGo* task, but comes back in the *Joint Go/NoGo* task.

The extended narrative thus suggests entirely different theoretical conclusions. First, there is no longer any reason to believe that the *Joint Go/NoGo* task carries the functional signature of a *Choice* task. Instead, it exhibits the signature of a selective response task, just like the *Single Go/NoGo* task. Second, there is likewise no reason to believe that social context acts to reinstate a choice-like Simon effect. Instead, the task-demands of selective responding seem to generate a new interference effect which is substantially smaller than the original (two-choice) one (see Figure 1.1).

On the one hand, the extended narrative provides a more complete and more precise account of experimental findings than the original brief one. Yet, on the other hand, it fails to offer an in-built explanation of the joint interference effect. As we have seen, the brief narrative offers such an explanation: if interference is associated with choice, it must be expected to come back when social context acts to instantiate the full choice task for each participant. This is what the action/task co-representation account claims (e.g. Sebanz et al., 2003, 2005). The extended narrative cannot resort to such an in-built automatism. Instead, it needs to come up with new ideas to explain the emergence of interference in the *Joint Go/NoGo* task.

Referential Coding

In what follows, we outline a framework of such ideas. As said above, the framework posits shaping rather than sharing task representations. More specifically, it claims that interference in the *Joint* task arises from shaping and tuning one's own task representation in a way that takes all events in the task scenario into account, including those arising from social context (e.g. events generated by another agent). How can this be possible?

Prominent views theorising about cognitive representations of action events (or the underlying mechanisms thereof; Hommel, 2010; Hommel et al., 2001; Prinz, 1987; see Box 1.1) refer in one way or the other to ideomotor theories of cognitive control (Harleß, 1861; Herbart, 1825; James, 1890; Lotze, 1852; for a review, see Stock & Stock, 2004). According to ideomotor theories, events (perceivable effects) are cognitively represented by codes of their sensory consequences. More precisely, the *theory of event coding* (TEC; Hommel et al., 2001) assumes that the cognitive representation of events consists of networks of codes that represent the features of all perceivable effects, such as the seen, heard or felt location, the direction and the speed, the effectors it involves and the objects it refers to (Figure 1.2; Hommel, 1997). In other words, cognitive control operates on the perceptual representation of events. Hence, these event representations (or the generation thereof) are per se independent of any prespecified stimulus–response mapping rules.

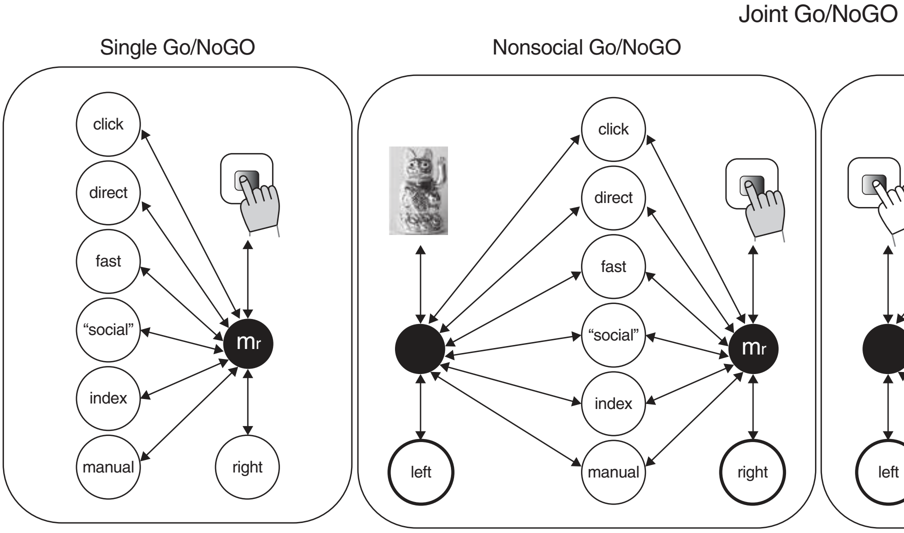

Figure 1.2 Referential coding in the *Single* (upper panel) and *Joint* (i.e. social or nonsocial) *G*

Notes: A prototypical agent (i.e. gray shaded hand) operates the right response key, which pr
consequences of these events might be described as something manual, direct and fast, produ
clicking sound that can be coded and are thus cognitively represented by these or any other e
the *Single Go/NoGo* Simon task, these event-features are typically shared between two alterna
with one exception: the location. Differentiating two (concurrently) activated event representat
features, i.e. the corresponding (response) location. This makes the agents’ right keypress be re
alternative event generated by, for example, another person or Japanese cat. Stimulus events th
activate the corresponding action event, leading (typically) to stronger interference effects in
the *Single Go/NoGo* Simon task, as there is simply no alternative event that needs to be differe
latter case unnecessary.

Box 1.1 The theory of event coding (TEC)

The theory of event coding (TEC; Hommel, 2004, 2009; Hommel et al., 2001) offers a theoretical framework for the representational basis of interactions between perception and action (and thereby an extension of the common coding (CC) theory; Prinz, 1990). In the tradition of ideomotor theorising (Harleß, 1861; Herbart, 1825; James, 1890; Lotze, 1852; for a review, see Stock & Stock, 2004), action and perception are considered as being (i) situated, i.e. tightly connected to on-going – and thereby constrained by rapid changes of – external or internal processes (Jeannerod, 1994), and (ii) inter-dependent and bi-directional (Hommel et al., 2001).

Common coding theories propose that action and perception share the same coding system, to the effect that the same representational structures (at least in part), which are responsible for the control of one's own action, are also involved in the perception of foreign action (Hommel, 2013; Prinz, 1990). Accordingly, common coding theories can be considered as the theoretical backup of neuronal assemblies that literally share common resources in perceiving and executing actions (known as mirror neurons in the macaque monkey (e.g. Gallese, Fadiga, Fogassi, & Rizzolatti, 1996; di Pellegrino, Fadiga, Fogassi, Gallese, & Rizzolatti, 1992; Rizzolatti, Fadiga, Gallese, & Fogassi, 1996) and a mirroring system in humans (for a review, see Rizolatti & Craighero, 2004).

TEC does not make any distinctions between perceived and produced events (stimuli and responses). Both are cognitively represented by codes of their sensory consequences. According to this reasoning, the cognitive representation of events consists of networks of codes that represent the features of all perceivable effects, such as the seen, heard or felt location, the direction and the speed, the effectors it involves and the objects to which it refers (see Figure 1.2; Hommel, 1997). In other words, the perceptual representations of events constitute the source of cognitive control.

Taking this parity between action and perception seriously, one would expect (i) facilitation of action execution based on direct prior perception and vice versa, and (ii) interference when action and perception recruit shared representations simultaneously. Meanwhile, there is a large amount of behavioural evidence that supports both action facilitation in the case of direct matches between perception and action (e.g. De Maeght & Prinz, 2004; Fagioli, Hommel, & Schubotz, 2007; for a review, see Heyes, 2001) and interference in cases of mismatches (e.g. Brass, Bekkering, & Prinz, 2001; Müsseler & Hommel, 1997; for reviews, see Schütz-Bosbach & Prinz, 2007; Sommerville & Decety, 2006).

As a consequence, and most critical for the extended narrative, this assumption implies that all events – irrespective and independent of their social/non-social nature – in a given task context are basically represented in the same way (i.e. by means of the same kinds of codes; Hommel, 2009, 2011). Hence, simply the assembly of perceivable events causes the *shaping* and *tuning* of one's own cognitive task representation. This in turn clarifies why response conflict (as in the underlying signature of Simon task interference) can be considered to reflect nothing more than the concurrent activation of more than a single action event representation (be it due to endogenous preparation, stimulus-induced activation and/or cross talk). Thus, irrespective of whether representing more than a single action-event alternative (as, for example, in the two-choice Simon task) or the perceivable consequences of another social/non-social entity (as, for example, in the *Joint Go/NoGo* Simon task), the set of action-event alternatives in the task context at hand attunes their cognitive representations. Accordingly, what matters for Simon-like interference is not the source of activation but rather the set of concurrently activated alternatives.

Being able to perform a *Joint* (social/non-social) *Go/NoGo* Simon task requires the actor to select the task-relevant representation from all concurrently activated action event representations. Consequentially, the requirement of selecting the event representation that encodes the corresponding action from a number of activated event representations reflects a discrimination problem. Emphasising features that discriminate task-relevant from task-irrelevant representations (i.e. through an increased 'intentional weighting' of discriminable features; Hommel et al., 2001; Memelink & Hommel, 2013) provides a parsimonious solution to this discrimination problem. In the Simon task the most obvious discriminating feature appears to be the (horizontal/vertical) location on which task-related action event alternatives are arranged (Figure 1.1 upper panel and Figure 1.2 lower panel; also see Dittrich, Dolk, Rothe-Wulf, Klauer, & Prinz, 2013).

Note, however, that any other feature can serve this function too, as long as it enables sufficient discrimination between (stimulus- and/or action-) event alternatives, and thus provides a reference for coding one's own actions. Such feature-based event discrimination is the key principle underlying the *referential coding* account (Dolk et al., 2013; see Sellaro, Dolk, Colzato, Liepelt, & Hommel, 2015, for a feature other than location, i.e. colour). In the case of spatial S–R compatibility paradigms, the spatial coding of one's own actions furnishes the representations of those action events with spatial features that will then interact with spatial features of stimulus events (see Figure 1.2). Consequentially, feature overlap of stimulus and action event codes will facilitate response execution in terms of matches as opposed to mismatches, impairing action execution (Hommel et al., 2001). In other words, feature overlap