

Formalising Performative Interaction

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Abstract. In this paper we attempt to formalise some of the basic attributes of performative interaction against a background of sociological analysis in order to better understand how computer interfaces may support performance. We show how this generic formalisation can be used in the deconstruction, analysis and understanding of performative action and more broadly in live performance. Two examples of this form of analysis are shown: the installation piece *Deus Oculi*; and Stelarc's *Ping Body* performance piece. The analysis of these pieces renders visible the varied (re)mappings of the causal nature of interaction, direct and indirect effects, and how these are perceived and exploited by the various members of performance social groupings. Our aim, then, is to provide a model that can be used to explore the relationships that exist in performative activities across domains.

1 Introduction

Computing technology has come to be used increasingly in many forms of performance in order to augment and extend (human) agents' ability [1] for performative action. Although this may be seen as part of a wider trend in art to engage with sciences [10], computer technology in particular presents the artist with ways of breaking some essential physical restrictions (such as location, e.g., mobile phones), and obfuscating causal relations between actions. The very nature of this use of technology in art also breaks from the original emphasis in human-computer interaction (HCI) of efficiency, and as such we have few means for investigating these breaks. Our interest, then, is in defining a formal method for describing performative actions.

2 What do we mean by performance?

While there are many, often conflicting, definitions of live performance, it is necessary that we point out that it is not our intent to create a new definition.

However, to improve the clarity of this paper, we must discuss what we include in our definition of live performance. We can view performance from many perspectives. For example, live performance may be seen as “tripartite interaction” [8], i.e., synchronous, real-time interaction that occurs between a number of agents (performers, participants and observers) implicated in a performance. Additionally, tripartite interaction falls within the “Performance Triad” model [8], where technology binds tripartite interaction to context and environment. Some models, on the other hand, only draw a distinction between a performer and a spectator and their transitioning relationship as mediated by the interface [5]. For the purpose of this paper, our approach is reductionist and focuses on the parts of the system (as with tripartite interaction). Later in this paper however, we introduce the key notion of ‘framings’:

- *Performers*: Construct the ‘frame’ of the performance, and perform to an audience with a particular (typically premeditated) intent.
- *Participants*: Interpret the ‘framing’ of the performance, and are engaged in the intended performance through some witting or unwitting activity.
- *Bystanders*: Also interpret this performance framing and although their presence is integral to the performance, their performative actions are not. They may also interpret a framing either wittingly or unwittingly.

Note that we consider the performative actions themselves (i.e., those actions conducted by participants and performers) to be very much part of the performance, not just the effects that are produced as a result of them (as discussed in [6]). Other definitions deepen this action-to-effect mapping, including, for example, gestures around the interface [5], however this is beyond the scope of this paper.

The concept of a performance framing here is central to understanding the background sociological concepts inside which our formal method is placed. The “frame” is a term developed from sociologist Erving Goffman’s work [3] broadly meaning a constructed context within the limits of which individual human agency and social interaction takes place. For example, a theatrical frame [3][pp. 124–155] involves the construction of a higher-level frame on top of a “primary framework,” i.e., the reality in which the fantasy takes place. In this example, actors assume a character, audiences suspend disbelief and events have their meaning transformed (e.g., compare the use of a mobile phone in public with its use in a theatre). We note that although all social interaction may be seen from a dramaturgical perspective, meaning everyday social interaction becomes performance in some sense [2], we deliberately narrow our analysis to cover more stabilised ‘established’ forms of performance. What this means, then, is that we define performance framings as an activity done within the intended frame “by an individual or group” who have some established knowledge about the frame, and are “in the presence of and for another individual or group” [7].

Also pertinent to this model is ‘intent’; participants and bystanders may perceive the performance differently than the performer intended. However, in this paper we do not focus on intention since intention rests with the makers

of the live performance (orchestrators, designers, technicians, etc.). We believe that intention is imperative to the understanding of HCI in live performance and yet this issue adds a layer of complexity that deserves its own careful analysis. Instead, then, we focus on the nature of observation and participation, and how technology changes bystander perception so that we may use this knowledge as an entry point for understanding the application of interactivity in this domain.

3 Overview

We begin with a generic model of activity and perception. This reflects the fact that much of performance is really about social action. We then go on to look at the beliefs (the reality of some being or phenomenon) that participants have about their actions and the effects of those actions. Together these enable us to produce (weak) definitions of witting and unwitting performative action based on beliefs about the effects of actions and the extent of the performative frame (that the being or phenomenon is part of the performance).

4 Actions

The key objects in performance are represented by two sets:

Agent

The set of all (human, animal, machine, etc.) agents involved in the performance.

Phenomenon

The set of all world phenomena that can be affected or sensed by agents. This includes real world physical things like cups, balls, etc., visual and aural things like the sound at a location of a room, and virtual things like the appearance of a web page. However, the directly perceivable phenomena are ultimately real world rather than virtual (e.g., the appearance of the screen on which the web page is shown).

At any moment and situation an agent has a set of actions available:

$$available_actions : Agent \rightarrow set(Action)$$

This and the other relations below will change depending on the current context and time. However to avoid repeating ‘ $Context \times Time$ ’ as parameters for every function we will take these as read.

If an agent actually performs an action at a particular moment we write this as ‘ $A[a]$ ’. Of course, this is only possible if the action is available:

$$A[a] \Rightarrow a \in available_actions(A)$$

These actions act on phenomena:

$$effect : Action \rightarrow set(Phenomenon)$$

However, in general there are also indirect influences due to physical or digital causal effects, for example the sound of played music may be picked up by microphones that create lighting effects, or dropping a glass may make a crash!

$$causal_link : Phenomenon \rightarrow set(Phenomenon)$$

Note that this *causal_link* will depend on the behaviour of technological and mechanical devices.

These causal links gives rise to a set of phenomena that are indirectly influenced by a person's actions and hence may influence others:

$$\begin{aligned} indirect_effect & : Action \rightarrow set(Phenomenon) \\ indirect_effect(a) & = causal_link(effect(a)) \cup effect(a) \end{aligned}$$

We write $A[a] \searrow p$ to mean that agent A performs action a that potentially indirectly affects phenomena p :

$$A[a] \searrow p \iff A[a] \wedge p \in indirect_effect(a)$$

5 Perception

Similarly each agent has a set of phenomena that can be perceived at any moment:

$$perceivable : Agent \rightarrow set(Phenomenon)$$

As with the case of actions, the causal links in the world mean that an agent may indirectly perceive phenomena not otherwise directly observable. (Note here that the inverse causal link function is being applied here.)

$$\begin{aligned} indirectly_perceivable & : Agent \rightarrow set(Phenomenon) \\ indirectly_perceivable(a) & = causal_link^{-1}(perceivable(A)) \cup perceivable(A) \end{aligned}$$

An agent may directly perceive the effects of another's actions if these sets interact. We write $p \swarrow A$ to mean that agent A may perceive phenomena p :

$$p \swarrow A \iff p \in indirectly_perceivable(a)$$

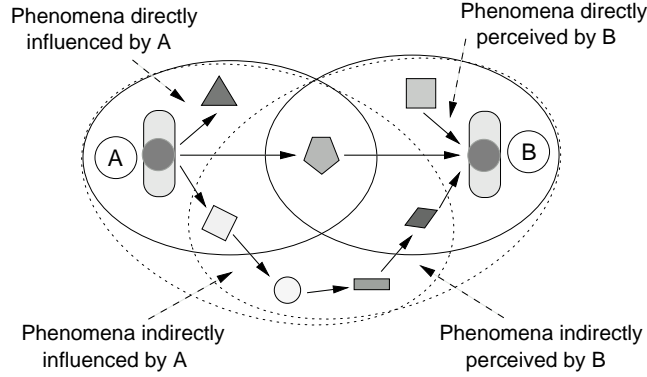


Fig. 1. Spheres of influence and perception

6 Influences

If the indirect effect of one agent intersects with the perceivable phenomena of another, then the actions of one may influence the other. We will write $A \searrow B$ if agent A potentially influences agent B :

$$A \searrow B \iff \exists a, p \text{ s.t. } A[a] \searrow p \swarrow B$$

Note that this is just representing that some action may give rise to a perceived effect. It does not necessarily mean that agent A necessarily performs the particular actions that may be indirectly perceived by agent B , nor that agent B actually notices the phenomena affected by agent A , nor even if the effects are perceived, that agent B realises that agent A is their cause. Figure 1 illustrates some combinations of influence and perception. We can consider a stronger conceptualisation of interaction by recognising that they can occur in two forms: actions by agent A that give rise to an effect perceivable by agent B ; and actions that give rise to an effect that is actually noticed by agent B . This, however, does not distinguish effects on B that may be unconscious or not the focus of attention (e.g., peripheral awareness), or ones that may not be perceived as being in any way explicitly caused (e.g., small changes in temperature).

7 Knowledge, frames and performance

A key difference between someone who acts and is observed or perceived in some way by another and one who actively performs for another is one of knowledge. To perform for another one must know that the other person may perceive the effects of one's actions.

We will write ' $\beta_A\{X\}$ ' to represent the current beliefs of A about the world (read ' $\beta_A\{X\}$ ' as ' A believes X '). If we perform for another then we must both act and believe that the other person will perceive our actions:

$$A \text{ performs.to } B \Rightarrow A[a] \wedge \beta_A\{A[a] \searrow B\}$$

This would include everything from speaking to someone to hitting a person on the head, but performances in the artistic sense require more. The participating agents have, in some way, to understand that their actions and effects are part of the performance. This is the role of the frame that was discussed earlier. Giving your friend a toffee during a play is not part of the performance, but an actor standing on stage and throwing the toffee probably is.

Each agent has different levels of experience in interpreting and making sense of framings. In this way performance framings are active and dynamic since they may be perceived differently by different people (e.g., a child and an adult). In the traditional theatrical context, it is commonly understood (although often also deliberately broken) as the time between the curtain rising and falling and the space on stage [3][p. 139]. In street theatre the physical and temporal boundaries are not so well defined. What is important is what people believe to be the frame.

As a simplification we will model the frame as a collection of phenomena (e.g., the things that happen on stage). Using this we can have a stronger definition of performance.

$$\begin{aligned} A \text{ performs.to } B \iff & A[a] \wedge \exists p \in \text{Phenomenon s.t.} \\ & \beta_A\{A[a] \searrow p\} \wedge \beta_A\{p \in \text{Frame}\} \wedge \\ & \beta_A\{p \not\searrow B\} \wedge \beta_A\{\beta_B\{p \in \text{Frame}\}\} \end{aligned}$$

That is, we must believe that our actions influence another through some phenomena, that these phenomena are part of the frame, and that the other person also believes the phenomena are part of the frame.

We can contrast this with the ‘unwitting performer’ who acts without knowledge that their actions constitute part of a performance:

$$\begin{aligned} A \text{ unwittingly-performs.to } B \iff & \exists p \text{ s.t. } A[a] \searrow p \not\searrow B \wedge \\ & \neg(\beta_A\{A[a] \searrow p\} \wedge \beta_A\{p \in \text{Frame}\}) \wedge \\ & \beta_B\{p \in \text{Frame}\} \end{aligned}$$

Note that there are two ways in which the unwitting performer may fail to understand that their actions are part of a performance. They may not know of the existence or bounds of the frame:

$$\neg\beta_A\{p \in \text{Frame}\}$$

or may not know of the effects of their actions:

$$\neg\beta_A\{A[a] \searrow p\}$$

The latter may occur because the unwitting performer does not understand the causal connections between directly influenced and indirectly influenced phenomena.

8 The effect of technology

Adding technological interfaces will change the available phenomena that can be acted upon (e.g., knobs, dials) or perceived (e.g., screens, sound from speakers).

Furthermore, technological interfaces can affect the existing phenomena and create new causal connections. For example, adding a microphone and speaker will make a causal connection between the sound near the microphone and the sound near the speaker.

Technological manipulations may even remove or weaken existing causal connections. For example, bright lights or loud sounds may block other stimuli.

Whilst physical linkages are readily visible, technological ones may be invisible. This invisibility means that those implicated in a performance may not know whether their actions will affect particular phenomena and hence, as noted above, they as participants or bystanders may unwittingly place themselves within the performance frame.

The act of discovering or understanding these connections effectively shifts one's perception of the boundaries of the performance frame. This thus creates changes in the way in which those involved may view their roles in a performance and so also affect their behaviour. This is exactly what occurs in *Deus Oculi*, which we shall now examine.

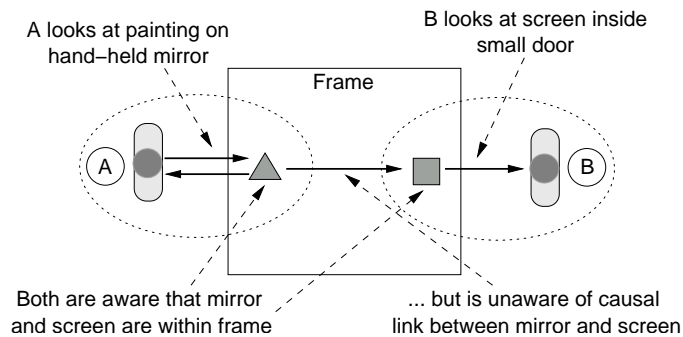


Fig. 2. *Deus Oculi*

9 Analysis of *Deus Oculi*

Deus Oculi was an interactive installation exhibited at the Chelsea International Crafts Fair in September 1999. This was a large renaissance-style painted scene featuring two figures whose faces were painted on small doors. Behind the doors were small CCTV screens that were linked directly to two hand-held mirrors situated on either side of the painting. When a visitor, assuming the role of a performer, picked a mirror and looked into it, an image of their face was captured on a hidden video camera and then displayed on one of the screens in the

painting. As a result, performers could not see the effects of their own manipulations resulting in highly engaging collaborative exchanges as the spectators pointed them out to the performers and/or bystanders [4].

Figure 2 shows the phenomena and frame in *Deus Oculi*. Two visitors, Alison (A) and Brian (B) visit the gallery and view the exhibit. The tableaux in Table 1 shows the various stages that they go through. Initially (step 1) they both realise that the mirror and screen are part of the frame. However, they are unaware that there is a causal link between the two.

At step 2, Alison looks in at the mirror and Brian looks at the screen however, the mirror and screen are linked by the hidden camera hence at step 3 Brian sees Alison's face.

At step 3 Alison is an unwitting participant. Looking back at our definition, the key phenomenon ('*p*' in the formula) is the screen. Brian believes the screen is part of the frame. Alison's action of looking at the mirror indirectly affects the screen, however Alison does not know that she is having this effect because she is ignorant of the causal link.

$$\left. \begin{array}{l} A[a] \searrow screen \swarrow B \wedge \\ \neg \beta_A \{A[a] \searrow screen\} \\ \wedge \beta_B \{screen \in Frame\} \end{array} \right\} \iff A \text{ unwittingly performs to } B$$

At this point however, Brian realises that there is some connection between mirror and screen and this is reflected in his changed beliefs at step 4. Brian does not share his new knowledge with Alison but knows that she does believe that the screen is part of the frame of the exhibit.

Now they swap positions. Brian looks in the mirror and makes silly faces whilst Alison looks at the screen. Similar to step 2 and 3, the hidden camera means that Brian's faces are visible to Alison. However, unlike Alison at step 3, Brian is aware of this link.

As he knows about the link it is not hard to work out that if he looks in the mirror Alison will see him.

$$\begin{aligned} \beta_B \{A[a] \searrow mirror\} \wedge \beta_B \{mirror \searrow screen\} \\ \Rightarrow \beta_B \{A[a] \searrow screen\} \end{aligned}$$

Of course, even with perfect knowledge some technical interfaces may be such that with bounded rationality we are not able to work out all such relationships, or they may only become apparent after a long time. However, in this case Brian does know that his actions affect the screen that Alison is seeing and that both he and she regard this as part of the exhibit's frame.

This makes him a witting participant:

$$\left. \begin{array}{l} \beta_B \{B[look_in_mirror] \searrow screen\} \\ \wedge \beta_B \{screen \in Frame\} \\ \wedge \beta_B \{screen \swarrow A\} \\ \wedge \beta_B \{\beta_A \{screen \in Frame\}\} \end{array} \right\} \Rightarrow B \text{ performs to } A$$

	actual situation	β_A (A's beliefs)	β_B (B's beliefs)
1. A and B come to the exhibit	$mirror \in Frame$ $screen \in Frame$ $mirror \searrow screen$	$mirror \in Frame$ $screen \in Frame +$ knows B's beliefs	$mirror \in Frame$ $screen \in Frame +$ knows A's beliefs
2. A looks at mirror, B looks at screen	$mirror \swarrow A$ $screen \swarrow B$ $A \searrow mirror$	$mirror \swarrow A$ $screen \swarrow B$ $A \searrow mirror$	$mirror \swarrow A$ $screen \swarrow B$ $A \searrow mirror$
3. B sees A in screen	$A \searrow mirror \searrow$ $screen \swarrow B$		
4. B infers relationships			$mirror \searrow screen$
5. A looks at mirror, B looks at screen	$mirror \swarrow B$ $B \searrow$ $mirror \searrow mirror \searrow$ $screen \swarrow screen \swarrow B$	$screen \in Frame$	$B \searrow mirror \searrow$ $screen \swarrow A +$ knows A's beliefs

Table 1. Tableaux of beliefs during *Deus Oculi*

Brian's actions, whilst not specifically scripted into the exhibit are expected. In acquiring knowledge about the performance frame Brian transitions from an unwitting to witting participant which gives him the ability to perform to an audience.

Brian's performative actions with and around the interface are tethered in a relatively linear fashion to the resulting effects (e.g., his face on the screen). This causal mapping enables swift (and humorous) transitions from unwitting to witting participant. Next we shall examine how these causal mappings themselves have greater depth, using Stelarc's *Ping Body* as an example.

10 Analysis of *Ping Body*

Ping Body, in contrast to *Deus Oculi*, is explicitly framed as a performance, rather than as an installation that encourages performative action. Stelarc performs his work, *Ping Body*, to demonstrate not how the body can be actuated by other bodies in other places, but how the body can be actuated by internet activity itself thus producing an inversion of the usual interface of the body to the internet. Not only is Stelarc's performance an event, but the performative interaction is an event itself [6]. A fascinating concept in this piece, then, is how this inversion exposes the complex and obscure causal mappings that constitute routine Internet activity, i.e., routine activity as would be experienced for the usual interface of the body to the Internet. In one performance Stelarc describes:

"We also used the ping Internet protocol in a performance where the Body was moving through internet data. During the performance I would ping 40 global sites. The reverberating signals were measured in milliseconds mapped to the body muscles in a very crude way, but what was effectively happening was that the body was becoming a barometer of Internet activity. The Body moved according to the internet activity from that global site." [9]

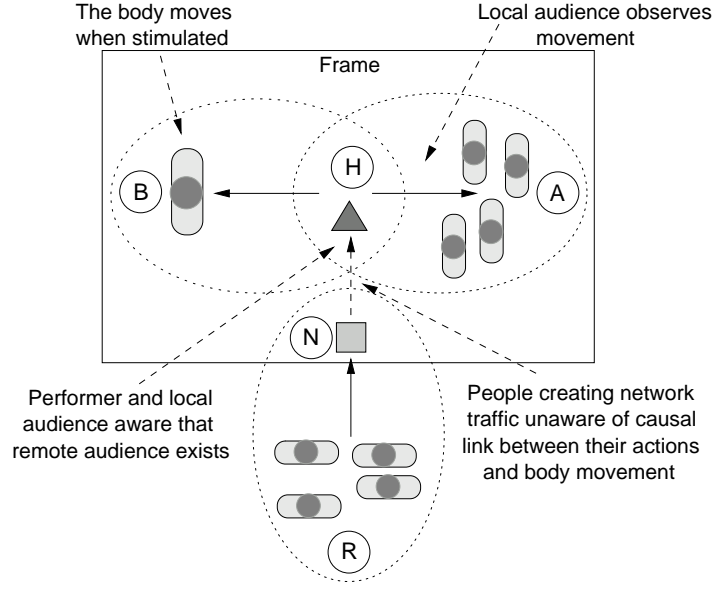


Fig. 3. *Ping Body*

Figure 3 illustrates the performative activity occurring in this performance.

Firstly we can decompose this in a similar way to *Deus Oculi*, drawing out the mechanics of unwitting and witting performance (unlike *Deus Oculi*, however, the participants in this case never know about their participation in the performance, and do not necessarily make the transition within the time span of the performance):

$$\left. \begin{array}{l}
 R[a] \searrow N \wedge \\
 N[a] \searrow B \wedge \\
 B[a] \swarrow A \wedge \\
 \neg \beta_R \{ R[a] \searrow B \} \wedge \\
 \left\{ \begin{array}{l} \{ R \in Frame \} \wedge \\ \{ \neg \beta_R \{ R[a] \searrow B \} \wedge \\ \{ N[a] \searrow B \} \end{array} \right\} \wedge \\
 \left\{ \begin{array}{l} \{ R \in Frame \} \wedge \\ \{ \neg \beta_R \{ R[a] \searrow B \} \wedge \\ B \} \end{array} \right\} \wedge \\
 \wedge \{ N[a] \searrow B \}
 \end{array} \right\} \Rightarrow R \text{ unwittingly performs to } A$$

The causal links between these unwitting participants (R) and Stelarc's (B) body movements are aggregated, which becomes part of this process of inverting the interface. Figure 4 illustrates several examples of different sets of causal linkages.

We might think of *Deus Oculi* as exploiting a relatively linear causal link, i.e., $A \searrow mirror \searrow screen \swarrow B$, Figure 4(a). Figure 4(b), on the other hand,

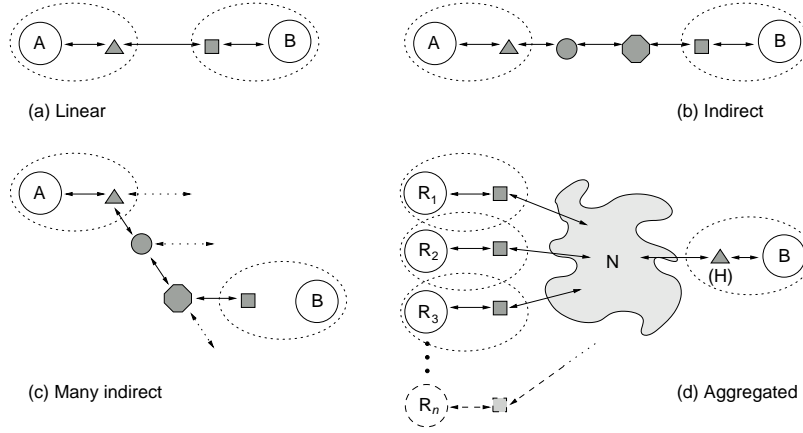


Fig. 4. An analysis of the causal linkages

illustrates a more obfuscated, indirect chain of causal links, e.g., $A \searrow p_1 \searrow p_2 \searrow p_3 \searrow p_4 \swarrow B$. We can even imagine a tree of indirect causal links, Figure 4(c). For *Ping Body*, however, these causal links are not only highly obfuscated causal links, but also aggregates of causal links such that (put crudely):

$$R_1[a] \cup R_2[b] \cup R_3[c] \cup \dots R_n[z] \searrow p \swarrow B$$

In short, then, we are able to unpack some of the elementary details that lie behind these experiences by assuming a simple formalisation of the various interactions that take place in both examples, *Deus Oculi* and *Ping Body*.

11 Conclusion

In this paper we have seen how performative acts may be formalised in order to understand how interaction with interfaces impacts performers, participants and bystanders, and how sociological aspects in turn impact this interaction itself. Some salient features of our formalisation are:

- The direct and indirect effects of actions performed by a (human) agent;
- Direct and indirect perception of those effects;
- Influences as the combination of indirect effects and indirect perception;
- Causal links that bind these together and their varying complex structures; and
- Wittingness and its relationship to the frame of performance.

Through our two examples, we demonstrated how this model may be applied in order to reveal the detail of interactions that may occur by virtue of the interface's configuration within a given setting.

The main application for such decomposition would be to direct the design of interfaces in order to craft certain experiences both for the performer of that system and, as we have also considered here, the resulting experience for participants and bystanders. Future work will be concerned with analysing further examples of live performance as well as applying this model as a design tool, in particular how it may be exploited and subverted in implementations of interfaces designed for performance.

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