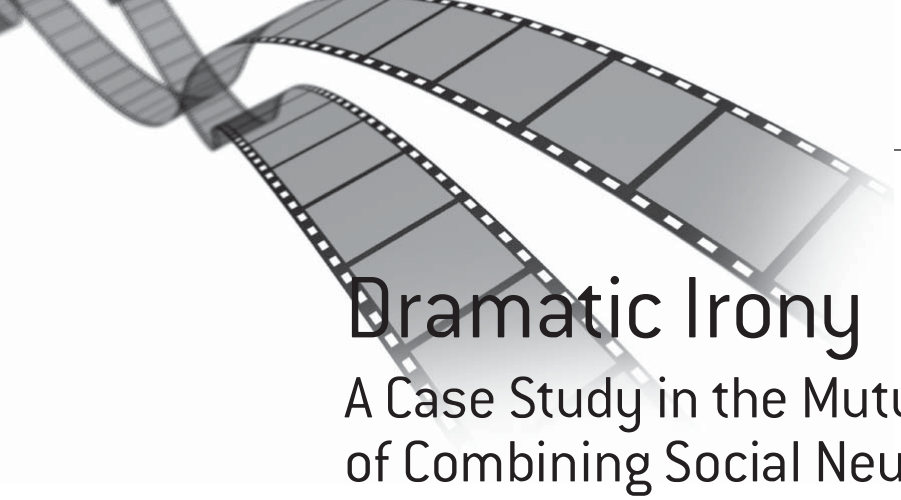

Dramatic Irony

A Case Study in the Mutual Benefit of Combining Social Neuroscience with Film Theory

Cynthia Cabañas, Atsushi Senju, and Tim J. Smith

Abstract: How do we understand the experiences of characters in a movie? Similar to real life, viewers attribute mental states to characters through a process known as Theory of Mind (ToM). Filmmakers commonly use Dramatic Irony, a narrative device where the audience knows something that at least one characters does not. From a social neuroscience perspective, understanding the cognitive mechanisms that underlie dramatic irony can provide a remarkable opportunity to study ToM in a more ecologically relevant context. While descriptive narrative theories of dramatic irony exist, these have never been studied in relation to contemporary social neuroscience. In this opinion piece, we aim to bring together these two traditionally isolated disciplines to propose a cross-disciplinary research roadmap for investigating the social neuroscience of dramatic irony in cinema.

Keywords: dramatic irony, film cognition, film studies, neurocinematics, social neuroscience, theory of mind

Let 'Em Play God. This title of Alfred Hitchcock's 1948 piece for *The Hollywood Reporter* emphatically captures what Hitchcock considered to be a key ingredient for suspense in his films: epistemic superiority. *Rope* (Alfred Hitchcock, 1948) might be the quintessential example of how he put this knowledge into practice. In the opening sequence of the film, as the camera pans over to a window with closed curtains, we can hear the scream of a man, suggesting the crime soon to be confirmed. The camera cuts then to the inside of the apartment, letting us witness the murder of David, strangled with a rope by his former university classmates, Brandon and Phillip. After hiding the body in a chest, they later host a dinner party while the guests are unaware of the content of the chest and are waiting for David to arrive. Such a simple difference in knowledge builds the tension and suspense of the entire film. Hitchcock let the audience *play God* by giving them the key information that most characters did not possess. This storytelling device, known as *dramatic irony*, places us a step ahead of those

doi: 10.3167/proj.2022.160106
Volume 16, Issue 1, Spring 2022: 84–104
ISSN 1934-9688 (Print), ISSN 1934-9696 (Online)

characters, letting us appreciate the diverging perspectives and the tension it creates. Such an insight is often presumed to come naturally to us since we do not have to explicitly think of doing it. However, it is actually a product of multiple complex social cognitive processes, crucial for real-world social functioning, which develop throughout childhood and into adulthood.

Advances in the understanding of cinematic dramatic irony have occurred through two traditionally separate paths of research—film studies and social neuroscience—whose findings can complement each other but are not generally integrated. Cross-disciplinary research can bring together these disciplines, setting common goals, creating new paradigms, and developing integrated knowledge for science and society (Morton et al. 2015), allowing us to address the gaps in knowledge about the social processing of dramatic irony.

Here we propose three key actions to enable this effective collaboration: (1) to blend theoretical frameworks from the concerned disciplines into an integrative whole to formalize constructs; (2) to behaviorally investigate the hypotheses informed by these frameworks; and (3) to explore the methodological avenues and resources available in the disciplines. This opinion piece first describes the structural mechanisms of dramatic irony from a film studies perspective; it then provides an overview of the socio-cognitive mechanisms that underlie this device; and finally, it sketches a roadmap of the key actions toward cross-disciplinary research, to exemplify how such research could produce cohesive explanations of the social neuroscience of film cognition phenomena like dramatic irony.

Dramatic Irony as a Powerful Narrative Tool

Use of Dramatic Irony in Filmed Narrative

The use of dramatic irony has been present in fictional narratives since their very beginning. It is a key element in Greek tragic style (e.g., Sophocles' *Oedipus Rex)*, and it was popularized in modern theatre by Shakespeare in some of his most famous masterpieces, such as *Othello* and *Macbeth*. Generally speaking, *irony* is understood as meaning the opposite of something, be it communicative intention (*verbal irony*), the result of an expected situation (*situational irony*), or the perspective of a dramatic event (*dramatic irony*). Although the term irony has proven challenging to define, given its diverse aspects, its definition often emphasizes the differential perspectives of a singular object and how those perspectives contrast (Goldie 2007). Similar to the use of perspective in painting, dramatic irony helps to create nuances by adding depth to a single event as seen from different viewpoints. It crucially exploits this disparity of understanding (Rutherford 2012), which may be tragic (as in romantic dramas), comical (as in screwball and silent-era comedies), or may create tension (as in horror and thriller films).

Most notoriously, dramatic irony is one of the principal tools to create suspense. In fact, the well-known example Hitchcock used to explain the difference between surprise and suspense is actually describing a scene of dramatic irony: if the audience does not know there is a bomb underneath a table and it explodes, "we have given them fifteen seconds of surprise at the moment of the explosion"; however, if the audience is informed about the ticking bomb, "we have provided them with fifteen minutes of suspense" (Truffaut 1985, 73). This prototypical Hitchcockian kind of suspense, directly related to dramatic irony, is called *vicarious suspense* (Smith 2000), and it has proven to be the most successful in producing prolonged anxiety responses, compared to other types of suspense (Bound 2016).

Structure of Dramatic Irony

Dramatic irony is entirely a product of directorial choices—through their collaboration with cinematographers and editors—regarding the distribution of story information (Bordwell et al. 2019). However, it has a distinct pivotal structure worth considering independently: crucially, one or various characters (known as the *victims of dramatic irony*) are not aware of certain information that is likely to provoke a *conflict* of some sort (Lavandier 2005). This conflict is of dramatic importance for the *victim*, potentially having a negative impact on either their physical, financial, or psychological wellbeing, e.g., *the bomb exploding* (see Figure 1 for examples in different films). For this reason, this storytelling device is an effective tool to create interest and engagement, since the audience feels the urge to help prevent that conflict but is unable to intervene.

Lavandier (2005) proposes a structure for dramatic irony, similar to the Structural-Affect Theory (SAT; Brewer and Lichtenstein 1982), in which the event order modulates the disparity of knowledge between viewer and victim, eliciting different affects, such as surprise, curiosity, or suspense (see also Tan 1996). As shown in Figure 2, there is usually an initiating event (*installation*), the moment when the viewer is shown information that the *victims* (in the *Rope* example, the guests of the party) do not know. The installation sets the formal expectation that this ignorance will create a conflict, bringing uncertainty and tension regarding its onset (Bálint et al. 2017). Sometimes, characters do have access to the same knowledge as viewers, but they are not consciously aware of it because of repression, denial, or mental illnesses (Lavandier 2005). This is the case in the film *Sunset Boulevard* (Billy Wilder, 1950), where the protagonist Norma Desmond is delusional and denies the fact that she is a forgotten silent-film star.

The scenes that follow generally support the construction of suspense, humor, or drama by staging the conflicting consequences of dramatic irony

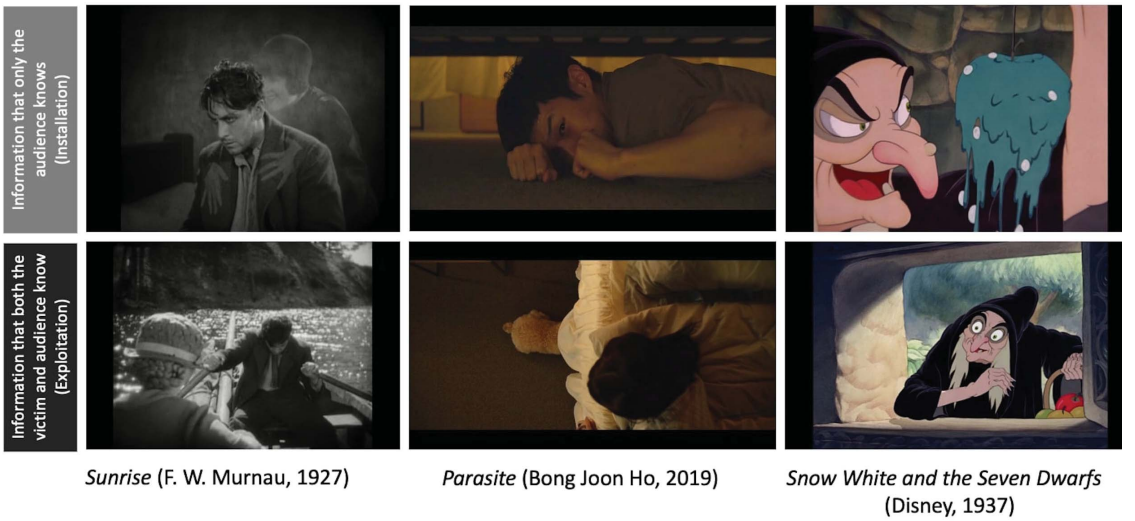

Figure 1. Examples of dramatic irony from diverse films. Top row depicts shots conveying information that is withheld from the victim of the drama (Installation). Bottom row depicts the peak of drama due to the conflicting knowledge (Exploitation). In Sunrise *(1927; Left column), a farmer is convinced by his lover to drown his wife so they can escape together. This positions the wife as the victim of dramatic irony when he later takes her on a boat trip. In* Parasite *(2019; middle column), a poor young man hides under the bed of his wealthy employer's daughter, creating tension when her dog starts sniffing under the bed. In* Snow White and the Seven Dwarfs *(1937; right column), Snow White is the victim of dramatic irony when we see her take a bite from a poisoned apple offered by her wicked stepmother in disguise. Credit: Sunrise: A Story of Two Humans (Fox Film Corporation, 1927); Parasite (CJ Entertainment., 2019), Snow White and the Seven Dwarfs (Walt Disney Animation Studios., 1937).*

(*exploitation*). They show the prospect of obstacles, misunderstandings, and traps the victim could fall into because of their ignorance (Lavandier 2005). Importantly, the words and actions of the characters in these conflict scenes have a different meaning for the viewer than they do for the victim(s). In *Rope* (Conflict 1 in Figure 2), for instance, Brandon prevents Mrs. Wilson, the housekeeper, from opening the chest to put some books inside. The audience can grasp why Brandon does not want her to open it, but she cannot. Both the disparity in knowledge and audience anticipation of the resolution (Oakley and Tobin 2012) produce in the viewer feelings of anxiety, worry, or hope on the victim's behalf. Finally, there often is an outcome event (*resolution*), the moment when the victim eventually learns what they did not know, prompting diverse affects in the viewers: empathy, sympathy, humor, etc., (Lavandier 2005). However, not all dramatic irony structures require an explicit resolution scene. For instance, the victim of the dramatic irony in *Parasite* (Bong Joon Ho, 2019), depicted in Figure 1, does not discover that the young man was hiding under her bed.

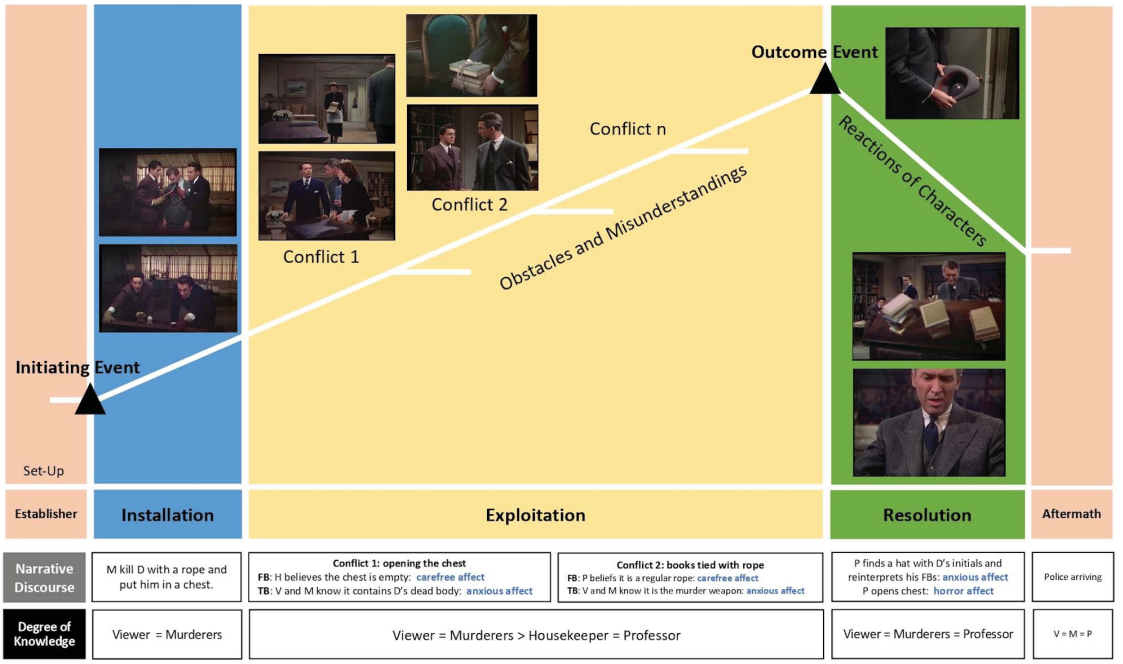

Figure 2. Schematic analysis of the dramatic irony structure of Rope *(A. Hitchcock, 1948). FB: False belief; TB: true belief; V: viewer; M: murderers; D: David; H: housekeeper; P: professor. Credit:* Rope *(Warner Bros., 1948)*

Formal Compositional Choices in Dramatic Irony

Filmmakers use a number of formal mechanisms to reveal, conceal or withhold the delivery of information. Some are shared with other narrative genres (i.e., literature or theatre), such as reverse storytelling, flashbacks, or dialogue. A good example of the latter is when a character in *Titanic* (James Cameron, 1997) says, "God himself could not sink this ship!"—the audience knows from the first scenes that the Titanic will sink after striking an iceberg.

However, many formal choices are medium-specific. Cinema allows for subtler delivery of information, manipulating audiovisual access to knowledge based on *editing*, decisions about what to include on and off-camera, and the choice of point-of-view (POV) through camera angles and positions (Branigan 1992). These elements include, but are not limited to: the *mise-en-scène* (e.g., the physical presence of characters, the occlusion of visual information as when characters are hiding behind a door or curtain); the framing of the shot, composition, lighting, zoom, and focus, which isolate or center important items, leaving other elements unfocused; and *extra-diegetic* devices (those not accessible to characters), including the musical score, genre conventions, or general knowledge about the world. For the resolution, the most important elements are *close-up* shots to show the ex-victims' reactions to the discovery of what was hidden from them before (Lavandier 2005).

Most films employ editing to highlight dramatic irony, for instance, by using cutaways to different scenes (multiple location montage) that re-

veal differential information from character to character, or reaction shots to convey the emotional expressions of multiple characters to different events. Some examples of how different shot choices are essential for communicating critical information are shown in Figure 1. *Rope*, however, exemplifies one of the most unconventional uses of cinematic formal elements to deliver dramatic irony. Hitchcock attempted to make the film look as though it was entirely shot in a single continuous take, seemingly happening in real time in one location. Therefore, *Rope* has a theatrical feel to it, where the *staging* and *mise-en-scène* become protagonists and where the camera movements simulate those of an invisible observer. The film's minimalistic editing style, with hidden cuts, invites the audience to focus on the conversations between the characters, which, in this film, deliver most of the irony (see MacDowell 2016 for a detailed analysis of *Rope*'s film properties to heighten dramatic irony).

Helped by the aforementioned formal compositional choices, which often exploit bottom-up (i.e., involuntary) attentional processes to draw the viewer's eye, it is the role of the spectators to infer what information is accessible to the victims and what is only accessible to them. But what does it mean to access this information? At what level of audiovisual narrative processing is this information represented? What kind of moment-to-moment processing is happening in the mind of the viewer? Over the years, cinematographers have intuited the practical use of these techniques. Nevertheless, these intuitions have been developed outside of current social neuroscientific knowledge about how viewers process social information and represent the content of characters' minds.

Theory of Mind as a Candidate Neurocognitive Mechanism Underlying Dramatic Irony

Similar to the way people interpret other people's behavior in the real social world, film viewers also systematically attribute goals, beliefs, desires, intentions, and emotions to movie characters through a process known as mentalizing or Theory of Mind (ToM; Premack and Woodruff 1978). Bordwell (1991) argues that spectators go beyond the information provided by the audiovisual medium, drawing inferences that they update as the narration unfolds, trying to predict what could possibly happen next. In the same line, ToM is a specific type of causal inferential activity, in which internal (or mental) states, such as desires and beliefs, are attributed to other people to understand and predict their observable behavior (Wellman and Woolley 1990). Films and their narrative devices, such as dramatic irony, go beyond following spectators' ToM: they exploit the ToM of the spectators. Specifically, the salient divergence of knowledge in these scenes prompts spectators to infer the character's mental states.

False Beliefs and Dramatic Irony

Central to the comprehension of dramatic irony is the concept of false belief (FB), a belief that is inconsistent with reality. In social neuroscience, FB tasks have been extensively used to assess mentalizing capacities, since FB understanding is considered a limit case in ToM computation. These tasks are conceptually similar to dramatic irony scenes in that they entail inferring someone's knowledge state and understanding that others (real people and/or fictional characters) may hold conflicting beliefs to our own that might not be supported by reality (in cinema, the *diegesis* or reality in the fictional world). Finally, these tasks require us to predict the actions and emotions motivated by this FB (Wimmer and Perner 1983). Ascriptions of FB are easier to examine than those of true beliefs, since the representational content of the latter is the same as reality, which fails to generate observable viewer responses when ToM fails.

Although these tasks come in different formats, perhaps the most popular version is the Sally-Anne Test (Baron-Cohen et al. 1985; Wimmer and Perner 1983). Participants are told a story about two agents, Sally and Anne, in which Anne moves a marble from a basket to a box during Sally's absence. The participant is asked to predict where Sally will search for her marble when she returns. Children around the age of three or younger often answer, incorrectly, that she will look into the box (where it really is) instead of the basket (where she last saw it), often interpreted as evidence that children in this age range cannot yet explicitly utilize false beliefs to predict behavior. In fact, acquiring an adult ToM that allows the comprehension of dramatic irony requires grasping multiple concepts that are acquired progressively throughout childhood (Wellman et al. 2001; Baillargeon et al. 2010).

Coincidentally, one of the most suspenseful scenes in *Rope*, previously described, appears to parallel the Sally-Anne Test: when Mrs. Wilson is naively about to open the chest, the suspense and tension are strongly heightened, since we know she falsely believes the chest is empty and therefore we can predict the consequences of her behavior. Viewers assume that characters' perceptions influence or constrain their beliefs and desires (Wellman and Woolley 1990). For instance, the audience can infer that Mrs. Wilson's belief is false, because she was not physically present during the installation scene; consequently, she does not have perceptual access to the same information as them.

Subcomponents of ToM and Connection to Empathy

It is worth noting that ToM is a complex, multifaceted construct, and can be differentiated into two subcomponents that would serve overlapping but different functions for film comprehension: (a) *cognitive ToM,* which refers

to inferring other people's desires, beliefs, or intentions and is critical for following the divergence of beliefs between viewers and characters (*Mrs. Wilson falsely believes the chest is empty*); (b) *affective ToM*, which refers to recognizing or inferring the feelings and emotions of others, allowing us to understand how characters feel as a result of their false (or true) beliefs (*Mrs. Wilson has a careless expression because she falsely believes the chest is empty*) (Shamay-Tsoory and Aharon-Peretz 2007; Völlm et al. 2006).

Importantly, although affective ToM processing is tightly related to *empathy*—the ability to share others' emotional experiences (Singer and Lamm 2009)—it does not automatically or necessarily imply empathy. For instance, viewers may not empathize with Mrs. Wilson as much as they may fear on the murderers' behalf that they might be caught. This example reflects the complex interaction between ToM and empathy in cinema, which often portrays multiple POVs of characters, allowing us to empathize momentarily, and potentially simultaneously, with them (for a neurocinematically informed review on cinematic empathy, see Raz et al. 2014). Both cognitive and affective ToM are built on the same architecture of mental states attribution and inferences, which would be crucial for enabling dramatic irony.

Positioning Dramatic Irony and ToM within a Wider Context of Social Cognition

The discovery of the *mirror neuron system* (MNS) in the human brain, considered a link between action observation and social skills (Gallese 2007; Keysers and Gazzola 2009) prompted the emergence of Embodied Simulation (ES) theory as an alternative approach to our understanding of others' behavior and experience (Gallese, 2007), questioning the primacy of mental state attribution as the computation behind social cognition. ES is proposed as a basic functional brain mechanism by which we use our own affective and sensory-motor neural circuits to map the emotional and somato-sensory experiences of others, therefore allowing immediate access to the meaning of others' emotional expressions and behavior, independent of an explicit attribution of propositional attitudes or mental states (i.e., desires, beliefs, intentions).

This theory, in turn, can be understood within the broader framework of embodied social cognition and interaction theory (IT), which puts emphasis on the embodied responses engaged in the interactive contexts in which social cognition takes place (Gallagher 2005; Hutto 2004; Lakoff and Johnson 1999); this emerged as a challenge to the traditional approaches to mindreading or ToM, such as Theory-Theory (TT), Simulation-Theory (ST), and their hybrids. All these mindreading accounts have in common the argument that propositional attributions are the primary way to explain and

predict behavior, although they disagree over which processes underlie this mentalistic attribution (Spaulding 2012). While TT argues that we rely on folk psychological theories (causal theories) about how mental states are related to behavior to explain and predict others' actions (e.g., Gopnik and Meltzoff 1997), ST, in contrast, claims that we explain and predict a target's behavior by using our own minds as a model to simulate how we would behave if we were in the other person's situation (e.g., Currie and Ravenscroft 2002; Goldman 2006); hybrid theories combine elements of both (e.g., Carruthers 2013). Similar to ES theory, IT proposes we can directly understand others in the expression of their overt behavior (Gallagher 2008) and argues that we rarely engage in complex operations of mental states attribution, since embodied responses are almost always sufficient for understanding other persons' intentions and behavior in daily social interaction, rejecting the idea that mentalizing underlies *all* social understanding. Adopting a phenomenological perspective, Gallagher argued that it is only "in cases where the situation is not typical, or when, perhaps, the behavior of the other person is out of character or out of context, or when we don't know the person, or in cases where we are talking with someone else about a third person" (Gallagher 2005, 210), where our basic evaluative understanding mediated by embodied processes fails, that we may resort to third-person-based explanation and prediction to understand others, as occurs in mindreading contexts simulated in cognitive experiments such as the Sally-Anne task.

Thus, we propose that dramatic irony would constitute one instance of such cases where "the situation is not typical" as referred to by Gallagher (2005), or the limit case situations that IT argues would be required for further complex explanation and prediction of the behavior of characters. Within the context of dramatic irony, as previously mentioned, spectators are put in a position in which, to understand the experience of a character, they must not only grasp what is happening directly from the character's behavior and expressions, but must also consider and integrate the context in which it happens (i.e., a character not knowing certain critical information), simultaneously representing two contradictory beliefs, their own and the character's, and infer how the character behaves as a result of their false beliefs. In *Rope*, only through this mentalistic operation does Mrs. Wilson's careless expression become coherent and comprehensible to us, since the interpretation of her emotional expression is conditional to the mentioned divergence of beliefs. Our position would be best aligned to moderate approaches to embodied social cognition (e.g., Michael et al. 2014), which can account for the complex representations that constitute dramatic irony comprehension: Instead of conceiving "embodied processes" as opposed to "mentalizing," these argue that both embodied re-

sponses and high-order cognitive processes, such as attention or working memory, play an important complementary role in mindreading (Michael et al. 2014). In this view, lower-order embodied cues, which may not be sensitive to propositional attitudes themselves, are coordinated and integrated with higher-level processes to enable the interpretation of others' behavior in complex situations that require observers to discriminate mental states, as is the case in false-belief-like scenarios such as deception, traps, or misunderstandings.

ToM Examination Using Film Stimuli

Social neuroscience has made great progress in our understanding of ToM mechanisms, but there are some methodological challenges that have created limits. In particular, the abstraction and simplification of stimuli (such as using puppets or cartoon vignettes) as well as excessive signposting, often introduced to ensure experimental control, contrast with real-world ToM processing, which can be very complex and subtle. This mismatch has proved problematic since researchers cannot guarantee the validity and generalizability of their studies (Zaki and Ochsner 2009). Consequently, researchers have started to embrace more (what many believe are) 'ecologically-valid' stimuli, such as films, since these involve complex *multimodal* information (visual and auditory) and they are *dynamic* and *contextually-embedded*, requiring the integration of different sources of context, both diegetic and non-diegetic, over time in a continuous flow (Zaki and Ochsner 2009; Bottenhorn et al. 2018). Precisely these characteristics make film particularly advantageous for examining the integration of social information over time, given that recent work has shown that regions associated with mentalizing processes operate on longer temporal receptive windows (Hasson et al. 2015; Lerner et al. 2011). However, to date, the temporal dynamics of ToM (i.e., when are mental states attributed?) remain largely unexamined (Király et al. 2018).

As stated above, movies are often described as *naturalistic* (or even ecologically-valid) stimuli because their viewing resembles real-life attentional, perceptual, and multimodal integration demands while also acknowledging their distinction from "real" stimuli due to their composed nature, that is, stylistic and practical deviations from reality such as shot composition and editing (Smith et al. 2012; Grall and Finn 2021). For this reason, in recent years, films paired with neuroimaging, such as functional magnetic resonance (fMRI; e.g. Hasson et al. 2004; 2008; Wagner et al. 2016; Richardson and Saxe 2019), have been extensively used to localize the brain regions underlying socio-cognitive processing. Nevertheless, it is important to bear in mind that movies are *crafted cultural products* that do not necessarily mimic the real world (Eickhoff et al. 2020; Holleman et al. 2020). For exam-

ple, understanding how the brain responds to movies may complement our knowledge as to how we process reality (Dudai 2012; Shimamura 2013; Smith et al. 2012), but Vanderwaal and colleagues (2019) point out that there are a number of *unnatural* formal devices common in mainstream movies—such as ellipsis, camera angles, zooms, cuts, extradiegetic music, flashbacks, etc.—that serve to streamline ordinary cognition processes by simplifying, emphasizing, or making redundant information for comprehension or aesthetic reasons (Newman 2006). Real-life social situations, which are disorganized in nature, rarely provide such opportunities. Thus, treating films as real-world (or ecologically-valid) events, neglecting the impact of these formal cinematic choices, can cause limitations in the neuroscientific interpretation and design of ToM investigations using film, whereas acknowledging these could be highly informative for their study. For instance, the suspense TV episode *Bang! You're Dead!* (Alfred Hitchcock, 1961; Season 7, Episode 2 of *Alfred Hitchcock Presents*), has been extensively used in previous neuroimaging studies (Hasson et al. 2008; Dmochowsi et al. 2012; Schmälzle and Grall 2020), although these have failed to address its conspicuous underlying dramatic irony structure (and related compositional choices) which could be very useful to examine complex and temporally-dynamic ToM processing.

By focusing on dramatic irony instances, which prompt limit case manifestations of ToM that direct viewers to infer and keep track of characters' true or false beliefs, we can leverage our knowledge about the film theory behind these moments and the compositional decisions made to realize them, enabling us to further understand multi-level ToM processing at behavioral, physiological, and neural levels.

A Roadmap for Cross-Disciplinary Investigation of ToM Processing in Dramatic Irony

In order to enhance our understanding of viewer's ToM use and FB inference in dramatic irony through cross-disciplinary research, we propose three key actions discussed in the following subsections. These suggestions by no means aim to imply that this is the only approach to cross-disciplinary collaboration. In fact, previous authors have put forward comparable triangulations of film aesthetic experiences (Smith 2011), inference generation in literary text (Magliano and Graesser 1991), film perception/comprehension (Smith at al. 2012; Loschky et al. 2019), or moving-image spectatorship (*Neurofilmology*; D'Aloia and Eugeni 2014), among others. These proposals generally share ingredients, including empirical investigation of the phenomenon of interest, 'objective' methods to examine its neural or physiological manifestations, content analysis of the formal elements of the medium, and borrowings from film theory/philosophy. Along similar lines,

we hope that this illustrative example serves as a starting point for future cross-disciplinary work on other film cognition phenomena.

Operationalizing ToM Processing in Dramatic Irony

A first step to examine how dramatic irony events are cognitively represented for spectators is to formalize their definition and compositional elements using a theoretical integrative framework. Based on current neuroscientific knowledge about scene perception, event perception, and discourse comprehension, Loschky et al. (2020) proposed the Scene Perception & Event Comprehension Theory or SPECT, which describes how attention, information extraction, and event model construction dynamically interact to enable viewers to perceive and understand visual narratives. SPECT constitutes a useful framework for operationalizing the levels of cognitive processing in dramatic irony, providing testable predictions not only about the roles of bottom-up mechanisms that may facilitate embodied responses prompted by formal features of the film, but, most importantly, for dramatic irony, the complementary role of higher order cognitive processes in enabling anticipation and comprehension of others' behavior in complex false-belief scenarios (Michael et al. 2014).

There are three relevant levels in the SPECT model. The first is front-end processes, which refers to *information extraction* from every eye fixation that helps decide where the eyes will go next (*attentional selection*). Films are carefully crafted products that filmmakers compose by use of bottom-up features to guide attention and create higher *attentional synchrony* (collective eye-gaze behavior). This includes the formal compositional choices used to deliver knowledge in dramatic irony information mentioned above.

Second, mid- to back-end processes enable the creation of a current Event Model (EM), which refers to our current cognitive representation of what we are seeing in the filmed narrative. These processes are related to working memory (WM), which allow the EM to be maintained and updated, until the former is stored in long-term episodic memory and a new one is constructed to keep track of the entire narrative. Executive processes are crucial to maintaining WM and reactivating key elements introduced in the installation, also serving to inhibit one's own perspective so that it interferes minimally, allowing one to see the contrast between beliefs.

A crucial question is: At what point in ToM processing do viewers start constructing an EM of characters' mental states? The canonical structure of dramatic irony can be of outstanding utility to elucidate the temporal dynamics of viewers' ToM use. In real-life social processing, individuals are often motivated to reason both *prospectively* about others' mental states during a particular event, and *retrospectively* to understand others' (congruent or incongruent) behavior (Király et al. 2018). Similarly, in dramatic

irony, ToM processing may be *prospective* (at the installation) or *retrospective* (at the conflict scenes or later on) depending on the choices of cinematographers/editors about how and when to deliver differential knowledge between characters and viewers. Critically, the timepoint at which viewers perform these ToM inferences will also determine the cognitive mechanisms recruited: attributing beliefs *prospectively* requires the maintenance of this belief (either in WM or LTM) over multiple scenes, allowing the viewer to predict its consequences or to update it, integrating incoming information about the characters' state of knowledge at the resolution; attributing beliefs *retrospectively* requires retrieving key episodic information that may have not been interpreted as relevant at the time, but that is currently revised to inform the attributed beliefs and construct a coherent model of characters' behavior. For instance, in Conflict 2 of the *Rope* example (Figure 1), viewers may not make the inference that the rope with which the books are tied up is the murder weapon (not grasping the conflict), until the character turns to the camera as if presenting the books to the audience, reminding them of the installed knowledge and prompting them to retrospectively infer the consequences for characters' beliefs and emotions.

Formalizing these processes with SPECT can provide a remarkable opportunity to identify where individual differences at different levels of representation may lie. For instance, there is considerable evidence that individuals with autism spectrum disorder (ASD) are less likely than neurotypical (NT) individuals to mentalize spontaneously without explicit instruction or task demand, but may perform successfully in ToM tasks attending to socially-relevant information when explicitly instructed to (Senju 2013). Thus, it is reasonable to hypothesize that this population would be less likely to consider a character's mental states in dramatic irony instances in free-viewing paradigms.

The third level in the SPECT model, extended back-end processes, refers to the access to long-term EM representations. These are especially relevant in dramatic irony structures for the mentioned retrospective revision of attributed beliefs, since often there are long protracted periods between the installation and the exploitation, requiring the reactivation of episodic memories. How do viewers integrate present information with episodic aspects of the EM that occurred before in the film, and how does this feed back to earlier stages regarding cinematographers' formal cinematic choices? Filmmakers often aid viewers in this inferencing process by stubbornly reminding them about the installation cues, prompting them to refocus and reactivate these inferences. This is exemplified by the framing of the camera in Conflicts 1 and 2 (Figure 1).

Following Hutson et al. (2017; 2021), we can design experiments to empirically explore these research questions suggested by SPECT, for in-

stance, to investigate the impact of formal cinematic mechanisms—such as the musical score or shot choices—on the different processing levels, and whether these can aid in ToM inferencing.

Behavioral Examination of ToM Processing in Dramatic Irony

Let us take the previous example of the influence of shot choice on ToM processing to address how we could go from a research question informed by film theory using an integrative framework such as SPECT to the empirical methods necessary to investigate it at all levels of neurocognitive processing.

To examine whether *close-ups* (in comparison to wider shots) draw attention to key visual and social information (*front-end processes*), we first need to identify different shot scale categories within dramatic irony structures using *content analysis*—a well-established research methodology in film studies (Brylla 2018)—to correlate them with behavioral measures (for a pre-existing shot scale dataset, see Savardi et al. 2021). We could also experimentally manipulate shot size directly to examine its effect on behavior, although, because of its complexity, at present, this has only been done in animation films (Rooney and Bálint 2019).

Next, we may use eye-tracking measures of viewers' *eye-movements* to test whether, depending on the shot choice, there are differences in which parts of the screen they attend to and extract information from (Smith 2013; Klin et al. 2002). We could then examine whether the shot choice had an effect on whether the information extracted was informative to create an EM and start making ToM inferences of false beliefs prospectively (*back-end processes*): Did the viewers process the installation scene as such? Or did they just process the information as trivial until the presentation of the conflict scenes, when they then retrospectively revised this information? To answer these questions, we need to explore what viewers understood from the installation and exploitation scenes by asking them to describe their thoughts about their understanding of the film as they watch it (*think-aloud protocols*; Trabasso and Magliano 1996) or to carry out comprehension questionnaires at different timepoints in the film after each critical phase, for instance. In this sense, it would be advantageous to conduct *event segmentation tasks* (Zacks et al. 2009) to examine the boundaries of viewers' EM and whether they create different EM for each dramatic irony phase. Finally, to gain insight into whether viewers are performing complex belief attribution processes that recruit WM processes (prospectively or retrospectively), we may also examine the online processing of dramatic irony scenes by presenting the film as a slideshow and asking viewers to press a button to progress from frame to frame, thus controlling their own viewing reaction times, which are taken as proxy for information processing time

(*self-paced viewing paradigms*; Cohn and Wittenberg 2015); or we may measure the impact of *dual tasks* on viewer's comprehension and reaction times with increased WM load tasks while watching the film (Hinde et al. 2018).

Physiological and Neural Examination of ToM Processing in Dramatic Irony

To further elucidate moment-to-moment ToM processing in dramatic irony, we can use online measurements of a viewer's bodily and brain states during film viewing. These include physiological measures, such as skin conductance and heart rate, which can gauge variations in affect and arousal; and electroencephalography (EEG; e.g., Dmochowsi et al. 2012), which can measure brain activity throughout viewing or in response to cinematic events (Event-Related Potentials). Both these measures can serve to examine the effect of shot scale on arousal and engagement, which can increase attentional focus at *front-end processing*.

Finally, functional neuroimaging, including fMRI or Near-Infrared Spectroscopy (fNIRS), can measure brain oxygenation levels as an index of region-specific processing demands and has proven to be not only useful to explore neural manifestations of film cognition but also to characterize individual variation. We may use dedicated analytical approaches to film stimuli to maximize its richness, such as *inter-subject correlation* (ISC) (Hasson et al. 2004), which extracts the commonalities in neural responses across different viewers watching the same film. Using *ISC* and *reverse correlation* analyses, we could take a set of brain regions identified a priori in fMRI meta-analyses of ToM networks—such as the temporoparietal junction or TPJ—and examine the kind of shot scales and dramatic irony phases for which brain response in the TPJ is high across subjects during a movie. Additionally, using *inter-subject functional connectivity* (ISFC), we can examine correlations between multiple brain regions across viewers to address the effect of shot choice on the functional and temporal dynamics between ToM processing, attentional, and empathy networks. For instance, we could explore the complex interaction between ToM processing and empathy (see Raz et al. 2014) and the effect of prospective versus retrospective ToM on how spectators experience affects and empathy related to dramatic irony, to understand whether they are really more engaged and pay more attention during these instances.

Importantly, movie fMRI studies that look at brain activity without experimental manipulation of the content or additional measures that correlate with observed brain response should not be taken as evidence of viewers' cognitive representations (a fallacy known as *reverse inference*; Poldrack 2006). Therefore, using continuous experimental measures, such as those above mentioned, would enable exploration of links between different levels of cognitive processing and neural dynamics (Eickhoff et al. 2020).

Concluding remarks

Dramatic irony is a storytelling device that occurs in all sorts of narratives, and is often critical for creating suspense. Notably, it also serves as a limit case of social processing, where both cognitive and affective ToM are essential for understanding the divergence between one's own beliefs and emotions and those of the victim. Thus, understanding the mechanisms that underlie this narrative device can provide a remarkable opportunity to study ToM with greater ecological validity, including aspects that have been neglected before, such as the temporal dynamics of ToM processing. Although descriptive theories of dramatic irony have identified a number of formal cinematic choices used to deliver differential knowledge, and cinematographers have intuited their practical use, these had not been informed by contemporary social neuroscience literature or vice versa.

In this opinion piece, we proposed a cross-disciplinary approach to tackle a common goal, which is, in this case, the gaps in understanding of the ToM processing in film and specifically its extreme manifestation in dramatic irony structures. Our purpose is to go beyond the use of film as stimuli, focusing on films as objects of study for examining film comprehension processes, mapping out their structures and elements using integrative frameworks such as SPECT in order to inform research questions and interpret behavioral and neuroimaging experiments.

In doing so, we will be able to advance in our understanding of both film comprehension and socio-cognitive processing, establishing mutually informative connections, and reflecting back the findings to the respective academic fields. Ultimately, cross-disciplinary research has the potential to foster tighter collaboration and dialogue between academic and media/film professionals regarding their formal compositional choices and their impact on the audience.

Acknowledgments

This work was supported by an Economic and Social Research Council (ESRC) PhD studentship awarded to CC. ESRC Grant Reference: ES/P000592/1

Cynthia Cabañas, MSc, is a PhD Student in the Department of Psychological Sciences, Birkbeck, University of London in the Cognition in Naturalistic Environments (CINE) lab under the supervision of Prof. Tim J. Smith and Dr. Atsushi Senju. She is interested in the role of theory of mind and empathy on film narrative comprehension and the cinematic formal features that filmmakers use to enhance these processes. Email: ccaban01@mail.bbk.ac.uk. ORCID: 0000-0002-2920-3907.

Tim J. Smith, PhD, is Professor of Cognitive Psychology in the Department of Psychological Sciences, Birkbeck, University of London and head of the Cognition in Naturalistic Environments (CINE) Lab (www.cinelabresearch.com). His research covers all aspects of visual cognition with a special focus on the active perception of real and mediated scenes (e.g., TV and Film) via eye movements. Email: tj.smith@bbk.ac.uk. ORCID: 0000-0002-2808-9401.

Atsushi Senju, PhD, is Reader in Social Neuroscience in the Centre for Brain and Cognitive Development and Department of Psychological Sciences, Birkbeck, University of London. His main research interest is the developmental origin of the "Social Brain" network, and its atypical development in Autism Spectrum Disorder (ASD). Email: a.senju@bbk.ac.uk.

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