Time in Video Games: A Survey and Analysis

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Abstract

This article introduces a conceptual tool for analyzing video game temporality, the temporal frame, and a methodology by which new temporal frames can be constructed as needed during analysis. A temporal frame is a set of events, along with the temporality induced by the relationships between those events. The authors discuss four common temporal frames: real-world time (events taking place in the physical world), gameworld time (events within the represented gameworld, including events associated with gameplay actions), coordination time (events that coordinate the actions of players and agents), and fictive time (applying sociocultural labels to events, as well as narrated event sequences). They use frames to analyze the real-time/turn-based distinction, various temporal anomalies, and temporal manipulations as a form of gameplay. These discussions illustrate how temporal frames are useful for gaining a more nuanced understanding of temporal phenomena in games. Additionally, their relationist characterization of temporal frames supports analysis and design.

Keywords

coordination, fictive time, gameworld time, real-time, real-world time, temporal analysis, temporal frame, temporality, time, turn-based, video games

A number of theorists have analyzed temporal phenomena in games. Some have examined ways in which time playing a game relates to the events in a game (e.g., Benford & Giannachi, 2008; Bittanti, 2004; Eskelinen, 2001; Juul, 2005). Other have identified design challenges such as how to integrate multiple time scales in a single game (e.g., Barreteau & Abrami, 2007; Ford & McCormack, 2000), managing the dynamic complexity of a game (Burgess, 1995), or the pacing and synchronization of activities

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(Thavikulwat, 1996). Any formal analysis of video games must account for temporality. One of the dominant experiential effects of video games as a medium is the sense of agency induced by the player taking meaningful action, action that influences future events in the game. The very concepts of "action," "event," and "influence" require an account of temporality in games—the myriad ways that temporal structure informs gameplay.

Consider the different temporal structures in PAC-MAN (1980), CIVILIZATION (1992), and ANIMAL CROSSING (2002). In PAC-MAN, when the player eats a power pellet, a "special event" is triggered; for a limited time PAC-MAN can defeat the ghosts that previously had been chasing him. In CIVILIZATION, the number of turns the player has taken is mapped against a calendar. The game begins in 4000 B.C. and can last through to the year 2100 A.D., although the player may experience this progression in a few hours. Finally, in ANIMAL CROSSING, the passage of time in the game is mapped to the passage of time in the real world. If the player plays at 3:00 a.m., he will find his diurnal neighbors asleep, while the nocturnal ones are anxious for interaction. As even these limited examples show, any account of game temporality must be able to describe a broad range of phenomena. Concepts such as duration, actions and reactions, time lines, turn taking, and calendars are just some of the temporal elements commonly seen in video games.

Our primary contribution is the introduction of a conceptual tool for analyzing video game temporality, the temporal frame, and a methodology by which new temporal frames can be constructed as needed during analysis. The concept of a temporal frame has been employed by other researchers. For example, it is not uncommon in studies of video game temporality to examine the relationship between the progression of events within the represented world of the game (what we would call gameworld time) and the progression of clock time as the player plays the game (what we would call real-world time). Many interesting relationships can be discerned between these two different temporal flows. What we have done is to recognize the generality of temporal frames. Where previous work has defined specific temporal frames that are assumed to cover the phenomena of game temporality, we have developed a definition of temporal frame uncoupled from any specific event progression. This supports the ability to define many possible frames as needed to perform an analysis of the temporal phenomena in a given game and also allows one to see the structure that is shared across all temporal frames (i.e., why the domain of gameworld events and the domain of real-world events each constitute a flow of time). More broadly, our approach is uncoupled from specific types of video games and can be useful not only for analyzing current commercial games but also board games, educational games, serious games, simulations, and so forth.

Our approach is as follows: We first describe our adoption of a relationist definition of time and discuss the relationship between this relationist definition and the subjective experience of time. This lays the groundwork for the next section, in which we define the concept of a temporal frame and describe several specific temporal frames that are commonly useful in the analysis of games. Our goal is not to exhaustively enumerate all possible frames but, rather, to introduce commonly useful ones as concrete examples. The real power of identifying temporal frames lies in analyzing the relationships between the different flows of time in the different frames. The next three sections give concrete examples from specific games of interesting relationships between frames, including a discussion of temporal anomalies and the explicit manipulation of time as a gameplay mechanic. We conclude with a discussion of related work.

Time

The literature on the philosophy of time commonly distinguishes Platonist and relationist understandings of time (Newton-Smith, 1980). For the Platonist, time is like an "empty container into which events may be placed; but it is a container that exists independently of whether or not anything is placed in it" (Stanford University, 2002). Thus, it is possible to conceive of all change ceasing throughout the universe for a period of, say, 1 year. For the relationist, discourse about time and temporal relations can be reduced to talking about events and the relationships between them. Without change (events), there can be no time.

As a methodological assumption for analyzing game temporality, we have found it useful to assume the relationist view. This allows us to tie temporal properties to player-perceived state changes (events) as well as define multiple temporal frames in terms of different domains of state changes. Every game has multiple temporal frames such as, but not limited to, those established by: hardware level state changes, state changes within the gameworld, and state changes in the real-world context in which the game is being played. The relationist approach to time allows us to both isolate these frames and analyze the relationships between them.

Temporal Structure and the Experience of Time

Our work is situated in the context of the Game Ontology Project (GOP), a hierarchical framework for describing structural elements of games (Zagal, Mateas, Fernandez-Vara, Hochhalter, & Lichti, 2005). The GOP generally brackets experiential and cultural concerns. However, perfect bracketing is not possible; structural categories often make (implicit or explicit) reference to experiential categories. This results in a tension between the phenomenological (experiential) and structural (descriptive) accounts of time in games. By adopting a relationist view of time, experiential concerns become manifest from the beginning in the notion of state changes associated with events.

In the relationist view, all talk of time can be reduced to talk about the relationships between events and thus to relationships between state changes in the world. Video games execute on a computational infrastructure, in which the fundamental state changes are the billions of computational state changes happening per second. Describing events at this granularity would achieve maximal precision but be incredibly onerous. Furthermore, players cannot perceive events at the level of individual instruction execution;

such an analysis would fail to provide a description of game time relevant to players and designers. The execution of instructions in the processor is simply too removed from the player's experience. Discussing the temporality of a game requires that a player perceive events and the relationships between them. Thus, an experiential category of perception is fundamental to a relationist account of time.

Experiential categories also play a role in both temporal cognition and the sociocultural references that reinforce a temporal fiction. Most of our understanding of time is a metaphorical version of our understanding of motion in space (Lakoff & Johnson, 1999). Common metaphors include time flowing past a stationary observer (e.g., "time flies by") and an observer moving relative to stationary temporal "locations" (e.g., "we've reached September"). Experiments have shown that people switch metaphors depending on the priming provided by spatial experiences (Boroditsky & Ramscar, 2002). Thus, the player's experience of time can potentially be manipulated or influenced through game design via tasks that trigger specific forms of metaphoric temporal cognition. This experiential aspect can be partially captured in a structural framework by developing ontological categories for the various metaphoric relations between embodied spatial experience and temporal cognition.

Sociocultural references can create a temporal fiction within the game world. For instance, video games can use either the passage of time, or real-world units or dates, to influence the perception of gameworld time. A game that "takes place" in the year 1492 mediates our understanding of the events that occur in the game. Playing a game where rounds are labeled as "years" also changes the player's experience of time. Inappropriate labels can break the player's suspension of disbelief. If the turns in CIVILIZATION were labeled as "days," the game would be "unrealistic" because the player could build the Great Pyramids in mere days. Finally, gameworld events may be experientially notable or significant through their participation in a narrative structure. In the beginning of HALF-LIFE (1998), the player moves a cart into a machine. This action triggers the disaster that plunges the Black Mesa research facility into chaos and motivates the rest of the game. Viewed purely as a state change within the gameworld, pushing the cart is undistinguished from many other player-initiated state changes, such as opening doors or firing weapons. However, this event is notable because the player understands that the game "happens" only because of that specific event. In our model, we capture the experiential aspects of sociocultural references through a temporal frame we call fictive time.

A deep understanding of temporality in video games requires multiple simultaneous perspectives, including the purely structural as well as cognitive and sociocultural aspects of time. Our relationist approach to time makes it natural to define multiple temporal frames in terms of different domains of reference events. Although the GOP is primarily structural and descriptive, temporal frames provide a vehicle for recuperating sociocultural references and (potentially) cognitive aspects into the model through the introduction of frames specific to those aspects. An analysis of game temporality then turns on identifying the temporal frames operating within a game and the relationships that hold both within and between frames.

Temporal Frames

When playing a game, say KINGDOM HEARTS II (2006), the player perceives many events. In the bedroom where the player is playing, the hands of a clock turn, street noises come in through the window, and the player's breath moves in and out. His or her avatar navigates different game spaces, moving continuously within locations, between locations or flying in spaceships between worlds. Additionally, he or she engages in a struggle against the Heartless and Organization XIII, piecing together the complex story that relates these enemies to the player character. Relationships between events constitute time; it follows that all of these events contribute to the temporality of the game. Rather than developing a single "temporal domain" consisting of the set of relationships between all these events, we have found it useful to identify specific event subsets, define a temporality relative to that subset, and then identify interactions between the times established by these different event subsets. In the example above, we would place the events happening in the bedroom (and the player's body) in one set, those involving the action of the player's avatar in another set, and those involving the story line in a third set. A set of events, along with the temporality induced by the relationships between events, constitutes a temporal frame.

Most games support multiple temporal frames that may overlap or occur sequentially. In the sequential case, different levels or player activities may establish distinct temporal frames. Some FINAL FANTASY games, for example, have distinct temporal frames depending on whether the player is involved in combat or exploration. In combat, gameplay is segmented by rounds; the player has time to decide what actions to perform while everything else is in stasis. When exploring, the game's temporality changes; inaction no longer prevents gameworld events from happening, requiring immediate actions and reactions from the player. When addressing the temporality of a game, it is thus necessary to identify and contextualize the distinct temporal frames that operate in the game.

We have identified four temporal frames commonly relevant for analyzing video games: real-world time, gameworld time, coordination time, and fictive time.

Real-World Time

Real-world time is established by the set of events taking place in the physical world around the player. These are commonly physical events happening in the location in which the game is being played, as well as in the player's body. These events establish a reference temporality outside of the game. This notion is more expansive than "play time," or the time taken to play a game (Juul, 2005). Play time addresses the duration of a play session but does not account for other temporal frame interactions, such as events in a game that depend on specific labeled times in the real world or on the passage of specific real-world durations. For instance, in the web-based game IKARIAM (2008), players build and develop towns to create a mighty island empire. Someone playing the game for a few weeks of real-world time will likely not have more than a few hours of play time because gathering resources and developing buildings requires the passage of real-world time. So a player may have to wait several days of real-world time for a building upgrade to be completed. Thus, a player actively plays for only a few minutes every day to make progress in the game.

The concepts of cycle and duration are two of the most fundamental relationships established between events in any temporal frame. A cycle is a sequence of repeating events, that is, a sequence of events in which a subset of the world repeatedly reestablishes the same state. Duration is measured by counting events in a cycle. We measure the length of time of a composite event, such as playing in a park, by beginning to count repeated events in some reference cycle at the event initiating playing in the park, stopping counting at the event terminating playing in the park—the number of repeated events we count is the duration of the composite event. In the real-world frame, such counting is facilitated by temporal measuring devices (clocks) that encapsulate reference cycles such as repeated pendulum swings or oscillations of a crystal.

Real-world durations (game world durations are analyzed below) often play a role in video games. Many games establish their duration in terms of real-world time. A game might last 10 minutes, segmented in two halves of 5 minutes each. Alternatively, a player may have an amount of time to meet a goal. Many games use a visual representation, such as a clock or counter, to communicate a time limit, literally displaying a reference cycle to the player. Triggers are another mechanism for relating to real-world durations. A trigger is an in-game event performed by the player that initiates a countdown of real-world duration. An event may occur at the end of the countdown, or the game rules may change during the countdown. In ALIENS VERSUS PREDATOR (1994), the player triggers the self-destruct sequence of a military complex. The player must then make his or her way to an escape pod before it is destroyed. As an example of the latter, eating a power pill in PAC-MAN establishes a countdown during which Pac-Man can eat enemy ghosts. Triggered countdowns may be communicated explicitly, via a clock (duration of the countdown is known), or implicitly, such as the ghosts turning blue during the triggered countdown in PAC-MAN (exact duration of the countdown is unknown).

Gameworld Time

Gameworld time is established by the set of events taking place within the represented gameworld—this includes both events associated with abstract gameplay actions as well as events associated with the virtual or simulated world (the literal gameworld) within which an abstract game may be embedded. Some games have multiple gameworld temporal frames defined by selecting subsets of gameworld events. For example, WOLFENSTEIN: ENEMY TERRITORY (2003) has a different temporal frame for each mission. Gameworld time applies to abstract games as well. TETRIS (1984) has a gameworld temporal frame established by event relationships, such as the time limit for making decisions about piece placement (before it is placed for you) or the triggering of a new piece falling on the placement of the previous one.

The gameworld frame can establish its own notions of cycle and duration that are potentially independent of cycles and durations in the real-world frame. For example, many games have a day-night cycle that establishes a new duration measurement in terms of gameworld "days." Gameworld days may be used to add atmosphere to a game (but not participate in the abstract rule system), to establish a time limit (which may have variable real-world duration since the passage of "days" can be affected by player actions), or may play a role in gameplay rules. In KNIGHT LORE (1984), because of the player-controlled avatar's transforming from human to werewolf, the day-night cycle directly affects gameplay. Cycles are also used to describe the behavior of other entities in the gameworld, such as enemy guards who might endlessly walk a patrol path.

Coordination Time

Coordination time is established by the set of events that coordinate the actions of multiple players (human or artificial intelligence [AI]) and possibly in-game agents. Coordination events are the markers that regulate gameplay through moments of synchronization and coordination. These events typically establish periods of play, limit availability of the gameworld, and/or delay the effects of in-game actions. For example, rounds are often used as a basic unit of play.The number of rounds played can trigger in-game events (e.g., reinforcements arrive on Round Three) or serve as a game goal (e.g., win before Round Five or best of three rounds). Turn taking, on the other hand, limits the availability of the game to one player at a time: You only act when it is your turn. Rounds and turn taking often, but not always, appear together. In poker, players are dealt cards each round and then take turns placing their bets. In Monopoly, players take turns rolling the dice and moving their game piece, but no notion of rounds is present (Darrow, 1934). Sometimes, the effects, or resolution, of the player's actions are not immediate. In tick-based games, such as AGE OF WONDERS (1999), players act simultaneously but need to wait until everyone completes his or her actions before a new round may begin. In poker, players wait until the betting is done before the winner can be determined. These basic building blocks for coordinating and synchronizing appear in many other combinations.

Other games use an abstract timeline for organizing the order of player or character actions. Depending on in-game attributes such as character speed, some characters may act multiple times before slower opponents. Actions can also be assigned a cost in action points (Björk & Holopainen, 2005), with points regained in succeeding turns. "Slow" or "Lengthy" actions may require a player to wait many turns before they can be carried out.

Fictive Time

Fictive time is established through the application of sociocultural labels to a subset of events. Labeling the rounds in a game as "days" or "years" changes a player's expectations of the granularity of action that can be accomplished in a round. Such expectations are established by activating temporal schemata in a player's mind, that is, cognitive scripts detailing default event sequences and relative durations. GUITAR HERO's "career mode" relates in-game progress with the temporal schema of a rock star's career path: Rock stars start as unknowns playing in small run-down establishments, gradually playing larger venues, and becoming more famous (Harmonix, 2005). Many kinds of temporal schemata exist. GUITAR HERO's (2005) career mode is cultural, while others, such as schemata of activity/recuperation, relate to biological cycles. For instance, characters may have to rest and/or consume food every so often in order to recover energy.

Representational elements strengthen the fictive frame; labeling the rounds as days or years in a game such as chess fails to establish a fictive frame. If a game includes additional representations that refer to sociocultural labels, such as calendars, day/night cycles, and visual representations that correspond to changes in "seasons" or "centuries," a fictive frame can be established and reinforced.

Fictive temporal frames are also established by association with a historical narrative. Crogan's (2003, pp. 282) analysis of COMBAT FLIGHT SIMULATOR 2 describes its gameplay "as play in and with a reconstruction of historical temporality drawn from the narrative modes of more traditional media such as historical discourse, historical archives, war films, and documentaries." The campaign mode of this game features missions based on conflicts of the Pacific theatre of World War II such that the fictive temporal frame in this game fosters player immersion via historical authenticity.

Games may contain narrated event sequences; within our framework, this is accounted for by borrowing temporalities described by narratology and employing them as specific subtypes of the general category of fictive frame. Specifically, narratology establishes a distinction between the chronological order of a series of events (story time), how these events may be narrated (discourse time), and the time of narration (narrative time). Collectively these are the narrative frames. Narratology identifies these coexisting times and describes how the reader or viewer must actively reconstruct story time from what was represented in the discourse, for example, reconstructing the story event sequence from a discourse sequence that makes use of narrative effects such as flashbacks, flash-forwards, and so on.

Cut-scenes, character dialogue, flashbacks, and other elements are often used to establish the narrative frames. The first-person shooter XIII (2003) includes levels with playable flashbacks depicting situations encountered by the player character prior to the main narrative of the game. Differences in audio, visual style, and character dialogue help the player understand he or she is playing a flashback of the main storyline. Narrative can also be established across multiple games. HALF-LIFE's (1998) expansions, HALF-LIFE: OPPOSING FORCE (1999) and HALF-LIFE: BLUE SHIFT (2001), are noteworthy because their fictive temporal frame situates them as occurring simultaneously with the original game. In HALF-LIFE: OPPOSING FORCE, the player controls a soldier charged with neutralizing Gordon Freeman, the protagonist of the original game. HALF-LIFE: BLUE SHIFT presents a third perspective of the Black Mesa disaster, this time through the eyes of a security guard. The player deduces the relationship between the expansions and the original game thanks to shared events, locations, and fleeting glimpses and references of Gordon Freeman's exploits.

Using Temporal Frames for Analysis

We have defined the concept of a temporal frame and described several frames that are commonly useful in the analysis of games (see Table 1). The power of identifying temporal

Table 1. Summary of Common Temporal Frames

Frame	Definition	Relevant Concepts
Real world	Real-world time is established by the set of events taking place in the physical world around the player.	Cycle, duration, countdown, trigger
Gameworld	Gameworld time is established by the set of events taking place within the represented gameworld.	Cycle, duration, countdown, trigger
Coordination	Coordination time is established by the set of events that coordinate the actions of multiple players (human or artificial intelligence) and possibly in-game agents.	Rounds, turn taking, tick based, action points
Fictive	Fictive time is established through the application of sociocultural labels to a subset of events.	Temporal schemata, sociocultural labels, story time, narrative time, discourse time

frames lies in analyzing the relationships between the different flows of time in the different frames. In the following four subsections, we give concrete examples from specific games of interesting relationships between frames. First, we explore some phenomena that occur from the interactions of the temporal frames we have identified. For example, we discuss the distinction made between real-time and turn-based games. Following that, we analyze why some games have a sense of temporality that is inconsistent, contradictory, or dissonant with our experience of real-world time. We call these phenomena temporal anomalies and identify some of the more common ones. Next, we examine games with explicit support for player manipulation of temporal frames. From a game design perspective, player agency over a temporal frame offers novel options for gameplay while also introducing additional temporal anomalies. Finally, we illustrate how you can define new temporal frames to gain additional insights.

Interactions Between Temporal Frames

Video games commonly possess multiple temporal frames. Common frame relationships include sequential frames (e.g., different frames for different levels), and coexisting frames (e.g., fictive and gameworld often coexist in a game). It is important to describe these frames and how they interact. For instance, ANIMAL CROSSING contextualizes its fictive time with respect to that of the real world. When the player first starts the game, he or she must enter the current real-world date and time. From that moment, the gameworld tracks time just as a clock in the real world would. The synchronization is such that by not playing on December 25, the player misses all the Christmas day in-game activities. The game also discourages the manipulation of the GameCube's system clock. Whenever a change is detected, the player is chastised by Mr. Resetti, a grumpy mole, for her "temporal manipulation." ANIMAL CROSSING exhibits a more nuanced relationship between fictive time and the other temporal frames than is commonly found in games.

Real-time and turn based. A common temporal distinction made when discussing games is that of "real-time" versus "turn-based" games. This distinction, often treated as a simple binary, masks a number of related phenomena resulting from the interaction of multiple frames. The theoretical structure of multiple temporal frames allows us to unpack the primitive, binary distinction into a more nuanced collection of related phenomena.

As a player interacts with the gameworld, he or she physically manipulates a controller (real-world control events) to cause events in the gameworld. When the player is allowed to cause gameworld events, we say that the gameworld is available. When no perceived delay between the control manipulation event (e.g., button press) and the corresponding gameworld event (e.g., character jump) exists, his or her actions are immediate. In PAC-MAN, the gameworld is available because the player is always allowed to move Pac-Man, and he moves immediately because no delay exists between input and action.

At times, perceptible events in the real world may not correlate with gameworld events, resulting in a "sluggish" or "non-responsive" experience. To the player, the experience does not seem "real-time" because of a lack of immediacy that was not part of the game's design. For instance, playing over a high-latency network can result in "lag": an extension of the time between a player's input and a perceived gameworld effect. Some games explicitly use action delays. In the first-person shooter XIII, a noticeable real-time delay exists between reloading a weapon and being ready to fire it again, decreasing the immediacy of reload actions. Here, the action delay emulates the physical action of reloading a weapon. However, if such delays existed for every action, XIII would suffer from a loss of immediacy and would feel less "real time."

If, in the coordination frame, a game makes use of turn taking, then the gameworld is not always available (Björk & Holopainen, 2005). This loss of availability is also seen in tick-based games, such as AGE OF WONDERS (1999), where, although they can act simultaneously, players must wait for others to continue playing. Loss of availability makes games feel less "real time" as well. NEVERWINTER NIGHTS (2002) mitigates this by allowing players to plan and schedule actions at any time. The game has a queued combat system where "you can select special combat actions for your character [. . .], and these are entered into your combat queue to be performed in the coming round" (BioWare, 2009). Players can queue multiple actions, but these are still executed one-per-round and transitions between rounds are determined by the passage of real time.

Games such as FALLOUT TACTICS (2001) limit the amount of real time available during rounds. Here, a player's inaction is penalized when it exceeds a certain amount of real-world time. Other games, such as MARIO & LUIGI: PARTNERS IN TIME (2005), although primarily turn based, allow players to gain bonuses by successfully synchronizing button presses in real time. These games manage to maintain a certain degree of availability despite being turn based.

A gameworld has liveliness if gameworld events continue to occur even when the player is not actively participating in the world (Gingold, 2003). Liveliness also

Table 2. Common Temporal Anomalies

Temporal bubble
Temporal warping
Nonuniform temporality
Hardware-related anomalies

contributes to the sense of a game being "real-time" When the gameworld is not lively, the player may stop taking action for indefinite periods of real-world time and have no gameworld events occur during this period. A game with high availability but no liveliness has some, but not all, of the temporal features we typically associate with a "real-time" game. FINAL FANTASY XII (2006) lets the player choose between two modes: active and wait. In active mode, the game does not pause while the player issues commands. In wait mode, the players have unlimited time to choose their next move. Here, liveliness is decided by the player!

We argue that the common distinction of "real-time" versus "turn based" results from a number of distinct interactions between the gameworld, coordination, and real-world temporal frames. Identifying these distinct interactions helps gain a more nuanced understanding of the phenomena that are masked by this binary distinction.

Embedded frames. Temporal frames may appear sequentially, overlap, and coexist. They are also often embedded in each other. This occurs with games included within games, such as the case of minigames. An embedded game may have a distinct temporality that is still related to that of the main game. In SHENMUE (2000), Ryu can visit an arcade and play fully functional versions of classic arcade games. The temporality of the embedded games is distinct from, and independent of, SHENMUE's. However, the time spent playing them correlates with time spent in the main gameworld. Players can play the arcade games to "pass time" in the main gameworld because certain places or events only became active at specific gameworld times. In contrast, in GRAND THEFT AUTO: SAN ANDREAS (2004), when playing the embedded arcade game DUALITY, time in the gameworld is "on hold." Playing DUALITY is equivalent to freezing the "outside" game and playing another one. The temporality of both games can be explained using the notion of embedded temporal frames, the essential difference between them being how they relate to each other.

Temporal Anomalies

The relationships between different, often coexisting, temporal frames within one game can result in a sense of temporality that is inconsistent, contradictory, or dissonant with our experience of real-world time. We call these relationships temporal anomalies (see Table 2).

Temporal bubbles can occur in the sequential transition between temporal frames. If a game begins in temporal Frame A, continues with B, and then goes back to A, a temporal bubble exists when, from the perspective of Frame A, no time has passed during the activity in Frame B. In GRAND THEFT AUTO III (GTAIII; 2001), the gameworld has a day-night cycle that advances as the player's avatar performs actions. However, whenever the player enters a building, time in the outside gameworld "stops," regardless of how much real-world, fictive, or gameworld time was spent inside the building. In GTAIII building interiors have their own gameworld time that is unrelated to that of the outside. Many computer role-playing games (RPGs) also have temporal bubbles between the temporal frame of combat and general navigation and movement. In combat, regardless of how many rounds a fight lasts, when the player "returns" to the regular world, no time has passed. Sometimes these anomalies are referred to explicitly in the games' narrative. In LEGEND OF ZELDA: OCARINA OF TIME (2003), when the player first enters Hyrule Market, he or she is informed that while in there, time does not pass "outside."

Another common anomaly is temporal warping. This occurs when at least two temporal frames overlap and an inconsistency exists between them. To eliminate the inconsistency, it is necessary to warp one temporal system (by compressing, expanding, etc.) to accommodate the other. For instance, in GTAIII, it takes roughly the same amount of time to perform in-game actions such as shooting or driving as it would to perform them in the real world. However, the game has a day-night cycle that only lasts a few minutes of real-world time. In-game actions take a proportionally longer fraction of a gameworld day to perform than they do in the real world. This anomaly also appears in games with a real-world time limit that is inconsistent with in-game time keeping. Juul (2005) describes a mission in GTAIII lasting 20 minutes of gameworld time, yet requiring 49 seconds of real-world time, with both times displayed simultaneously on screen. This illustrates temporal warping between the gameworld and real-world frames.

A game's temporality is non-uniform when the passage of time is unevenly distributed across different temporal segments (coordination units). For example, consider a game segmented into rounds. If, according to the fictive temporal frame, the duration of each round varies, a nonuniform temporality exists. In CIVILIZATION, each round initially corresponds to 200 years in the fictive frame. Toward the end of the game, rounds correspond to only 1 year. This can create an experience of temporal compression where events toward the end of the game are perceived to occur more slowly (it takes longer for a year to pass), despite the fact that in terms of coordination time, no changes occurred (a round is still a round).

Usually the hardware frame is irrelevant to player experience because hardware events are not directly perceived. Occasionally, however, the relationship between gameworld time and real-world time is not uniform across different hardware configurations. Many older video games are unplayable on faster computers because the amount of real-world time taken by gameworld events directly depends on processor speed (the main game loop is not throttled). On faster computers, these games are unplayable because game entities move too fast. Another anomaly, slowdown, occurs when the complexity of the gameworld exceeds the capacity of hardware resources. In such cases, typically caused when too many objects are on the screen, gameworld events occur in "slow motion" (take longer in real-world time than usual). Similarly, some players experience network

Table 3. Common Forms of Temporal Manipulation

Temporality as Gameplay
Manipulating coordination time
Pausing, starting, and stopping gameworld time
Manipulating the relation between gameworld and real-world frames
Manipulating the relation between gameworld frames
Manipulating the fictive frame

lag that can result in them observing their enemies zooming around them while they can hardly move at all.

Time as Gameplay

Some games allow the player to manipulate and affect the temporal frames we have described (see Table 3). In these cases, temporality is used as an element of gameplay with the game's temporality defined in part by the player's possible actions. Player agency over a temporal frame can offer novel options for gameplay as well as introduce additional temporal anomalies.

Manipulating coordination time. Coordination time is established by the events that coordinate the actions of multiple players (human or AI). Games that allow players to manipulate said coordination provide a form of temporal manipulation. For instance, some traditional board and card games allow players to "pass," or forgo their turn at play. Similarly, players may be penalized with the loss of a turn or rewarded with additional turns. Manipulations that alter the order of play are essentially about manipulating coordination time. In the board game Power Grid (Friese, 2004), the order of play is determined by the current standing in the game, and players may strategically try to position themselves so as not to play first.

These concepts also appear in games where player's actions are not directly coordinated (such as in turn taking). When a player-controlled character is killed in TEAM FORTRESS 2 (2007), the player must wait a certain amount of real-world time before he or she may reenter (respawn in) the game Meanwhile, the other players continue playing and gameworld time moves along as usual. From the perspective of the player, however, he or she must "lose a turn," where "turn" is equal in this case to an interval of real-world time. In WOLFENSTEIN: ENEMY TERRITORY (2003), players using the medic role can revive characters that have been killed. When killed, a player has the option of "tapping out" and waiting for the next respawn interval or waiting in-game, hoping a medic will revive him or her. Thus, the amount of time spent removed from play is variable, depending on how quickly medics in the vicinity respond.

Manipulating gameworld time. Temporarily suspending, or pausing, gameworld time (relative to real-world time) is another common temporal manipulation. The idea is that no events occur in the gameworld while gameworld time is paused. It can be used for gameplay reasons such as allowing the player to perform gameworld actions while the game is paused. Many computer RPGs allow players to access inventory screens and make changes to their characters while the game is paused. On unpausing, the changes come into effect immediately. Similarly, players can often effect changes to the gameworld even as it is paused, for example, by healing wounded characters. This notion is not unique to video games. Some professional sports allow for a "time-out" that effectively suspends gameworld time, allowing coaches to plan or communicate strategies and instructions. In other cases, gameworld time is suspended while players assume certain positions on the field, such as when executing a free kick in football (soccer).

Players may also have agency while gameworld time is suspended and lose it when it is not. For instance the player may have to organize the gameworld's entities so that when gameworld time is started, gameworld events occur such that the game's goals are met. THE INCREDIBLE MACHINE and CHUCHU ROCKET! (1999) are examples of this. The object of CHUCHU ROCKET! is to guide mice around a board into goal areas by placing tiles with directional arrows on the floor. Gameplay centers on the appropriate placement of the tiles because, when gameworld time is started, the player can only watch as the mice make their way to the goals, hopefully avoiding any cats.

The relationship between gameworld time and real-world time is also often manipulated. Sometimes this is accomplished via hardware. The NES Advantage controller for the Nintendo Entertainment System console includes a special button labeled "Slow." Players are instructed to "use this feature to get through difficult portions of games where the action gets too fast" (Nintendo, 1987). The relation between gameworld time and real-world time sometimes changes across different hardware configurations (see hardware-related anomalies above). However, here we are interested in game mechanics where the player is provided control over the frame's relationship. For example, players may alter the ratio of events in the real world with that of the gameworld. If an event occurs in the gameworld every 6 seconds of real-world time, the player may effect a change so that it occurs every 3 seconds. In this way, the player has accelerated the gameworld's time (relative to the real world). Conversely, if the gameworld event were to occur every 12 seconds, the gameworld's time would have been decelerated. This is like imagining that the gameworld has an internal clock and the player can make it tick faster (or slower), thus speeding up (or slowing down) all of the events in the gameworld relative to the real world. SIM CITY 4 (2003) provides three settings of simulation speed controls that allow the player to change the speed at which time passes in the gameworld. In MAX PAYNE (2001), the player can activate "bullet time," a form of deceleration of gameworld time with respect to real-world time that allows Max to perform acrobatic combat maneuvers. Because the speed with which the player can move the mouse/cursor remains unchanged, it is easier to aim. This allows the player to be more effective in dispatching opponents in situations that would prove insurmountable in "regular" time.

A similar form of manipulation exists when players can restore a gameworld's temporal frame to a previous state. Often, such as in PRINCE OF PERSIA: SANDS OF TIME (2003), this manipulation is represented as if gameworld events were recorded on a linear medium such as videotape. Here, the prince has the ability to "reverse" time. While reversing time, all sounds and previous action play backwards, and the gameworld accurately resets to an earlier state (Atkins, 2007). If the prince was struck by an enemy during this period, the health he lost is returned, or a recently destroyed bridge will repair.

The relation between coexisting gameworld temporal frames can also be manipulated. For instance, the player may affect the ratio of events in one gameworld temporal frame with respect to those of another such as when using items that slow down or freeze time only for enemies.

Relations between gameworld frames. Some games present a unique type of overlapping frames where gameworld time, or a subset of gameworld events, from a player's earlier actions in the game overlaps the current gameworld time. Many racing games allow players to race against a visual representation of an earlier version of themselves playing the same game. This visual representation, or ghost racer (ghost player in the context of nonracing games), does not exist in, or affect the gameworld in which it is represented in any meaningful way. So, a player cannot ram a ghost racer, for example (Sandifer, 2006). However, not all the gameworld events from the player's earlier play are necessarily overlapped. Gameworld events associated to the interface are typically not included. In other cases, the ghost player may have an effect on the current player. ELITE BEAT AGENTS (2006) features a multiplayer mode that allows a single player to play against a saved replay that can hinder the current player by making the target markers smaller.

More recently, game designers have begun to explore these overlapping temporal frames by adding gameplay significance to the interaction between earlier and current gameplay. Games such as BRAID, CURSOR*10 (2008), and TIMEBOT explore what would it mean if your ghost could interact with you? CURSOR*10 instructs the player to "Click stairs and move" while also cryptically hinting that to be successful, a player must "Cooperate by oneself?!" In CURSOR*10, the player must reach Floor 16 by finding and clicking on (up) stairs in each room. The player has 10 attempts (or cursors). Each cursor only exists for a limited amount of real-world time. Once that time runs out, the player starts over with the next cursor. However, all the earlier cursors also appear. However, their actions (the player's actions earlier in the game) have an effect in the "present." For instance, some levels have buttons that, when held down, make the stairs appear. In these levels the player must "use up" part of a cursor's lifespan so that when he or she reaches the same floor, his or her future cursor can click on the stairs and gain access to the next floor.

Manipulating the fictive frame. Sometimes, the fictive frame allows for the player-controlled character to manipulate time. Broadly speaking, these games' narratives incorporate notions of time travel, manipulation of space-time and similar concepts. Usually, the temporal manipulation is framed under the notion of requiring the player to change events in a fictive past so as to affect the fictive future. Games that allow manipulations of the fictive frame include CHRONO TRIGGER, SHADOW OF MEMORIES, DAY OF THE TENTACLE, LEGEND OF ZELDA: MAJORA'S MASK, and TIME HOLLOW.

In SHADOW OF MEMORIES (2001; SHADOW OF DESTINY in the United States), the player controls Eike Kusch. The game begins as Eike is murdered, and the player must prevent his murder in the fictive present while investigating the mystery surrounding it. Over the course of the game, the player visits four eras. Eike's survival in the present requires doing things in earlier eras that have an effect on later ones. For example, in 1980, Eike receives an egg clock. If Eike travels to 1908, he can give the egg clock to the owner of a bar. This causes the owner to start a hobby: collecting oval-shaped objects. This hobby is then shared by his descendant in the fictive present. When Eike gives the current bar owner another egg, in gratitude he gives Eike a frying pan that ultimately saves his life.

A fictive frame may also contextualize, explain, or otherwise rationalize gameworld events. In his analysis of PRINCE OF PERSIA: SANDS OF TIME, Davidson (2008) explains how (most) of the game is situated in the context of the Prince narrating a "tale like none you have ever heard" to a young woman. In keeping with the idea that (most) of the game is a narration of events, when the player is not able to successfully complete an acrobatic feat, "the Prince speaks in voiceover, saying 'Wait, wait . . . that is not how it happened. . . . Now, where was I?' and you are reset to the spot right before you accidentally leapt to your demise" (Davidson, 2008, pp. 362). Thus, unsuccessful gameplay events never "happened" in the fictive frame, they are simply mistakes on the part of the storyteller who misremembers what occurred. Once the players successfully complete most of the game, they encounter a twist wherein, because of "saving the day," everything the players have done in the gameworld is "whirled away within the context of the story" (Davidson, 2008). The character Farah, who had accompanied the prince throughout most of the game, turns out to be the young woman who is being told the story of the events that no longer have happened.

Many games incorporate many (or all) of the temporal manipulations we have discussed. In BLINX: THE TIME SWEEPER (2002), the titular character is an anthropomorphic cat dedicated to the locating and correcting temporal glitches throughout the universe. Blinx's raison d'être is manipulating the fictive temporal frame. Blinx wields a device providing him with six different temporal manipulation controls: REW, FF, Pause, REC, Slow, and Retry. The REW control, for example, causes gameworld time to run backwards for everything in the gameworld except Blinx. Interestingly, elements previously destroyed can be restored regardless of how long ago they were destroyed. The REC control is used in two phases. The first phase consists of 10 seconds of real-world time during which Blinx is invulnerable to all damage and can move normally. After that, the gameworld and Blinx are rewound by 10 seconds. This temporal frame is then overlapped with the current one. The actions taken by Blinx during the "recording" are represented by a green ghost that has an effect on the current gameworld. Thus, the player solves puzzles normally requiring two characters.

Defining New Frames

One of the contributions of the temporal frames approach is that different temporal frames can (and should) be defined. For instance, temporal frames can be used to define and isolate specific phenomenon in a game we want to analyze. For example, consider the cooperative zombie first-person shooter game LEFT 4 DEAD (L4D; 2008). One of the game's design innovations is the AI Director; a system designed to control the pacing and player tension in the game by, among other things, placing enemies and items in varying positions as well as determining when and where key events such as encounters with special enemies will take place (Booth, 2009a). The Director arranges events to increase tension while allowing for lulls in between because this helps create a dramatic and exhilarating experience of mounting tension.

From a player's perspective, what elements does L4D use to help create a sense of mounting tension and how can we describe their temporality? How does L4D achieve this while providing an experience for four human players who are doing different things in the game? For the purposes of this limited analysis, we could focus on examining the game's interface and explore which events are communicated to the player and how they are presented. We define the *Interface Frame* as the set of events that take place in the game's user interface. We argue that the relationship between events in this frame and L4D's gameworld frame play is central to creating an intense play experience and promote player collaboration.

In the game, it is possible for players to be rendered helpless and thus require assistance from others. For example, they may be dangling from a ledge or incapacitated on the ground. When players assist each other, both see an indicator in the middle of the screen that describes the action being carried out, as well as a progress bar that slowly fills up. This serves as an indicator that the assistive action does not occur immediately (compared with, say, picking up ammunition). It also gives players a sense of how much longer there is, in real-world time, before a task is completed. Additionally, because the bar is sometimes reset, for example, when attacked, the player is informed that that task is one that is interruptible.

The notability of certain gameworld events is reinforced by their appearance in the game's interface. For example, when a player kills a special zombie, a message appears on-screen indicating who killed the monster as well as its type (e.g., "Francis killed Smoker"). If another character saves you, this is also highlighted via the interface ("Francis saved you"). The interface is also used to inform the players of upcoming gameworld events. For instance, the future appearance of the special zombie "The Tank" is preceded by its distinctive nondiegetic music (Booth, 2009b).

Players can also communicate via a standard text-based chat interface with messages that scrolling upwards. In L4D, recent messages appear at the bottom and are also brighter. Older messages eventually fade out and disappear. Similarly, when a player is attacked, a red arrow appears on screen indicating the general direction of the attack. Because the arrows eventually fade, the interface also communicates how recent a particular attack was. We can thus see how the game's interface and in particular the Interface Frame mediate the player's experience by serving as a record of the temporality of past events in the gameworld, foreshadowing future gameworld events and also recording events that are outside the gameworld.

Discussion and Related Work

We build on prior work that has identified some of the key issues and concepts related to time and video games such as recognizing that games have more possibilities for temporal structuring than cinema or live theater (Wolf, 2001). The player and his or her actions play a crucial role in realizing the temporality in a video game, and the sense of experienced time is determined by the actions carried by the player together with the events enacted by the controlling program (Aarseth, 1999). Other authors have examined ways in which time playing a game relates to the events in a game (Benford & Giannachi, 2008; Bittanti, 2004; Eskelinen, 2001; Juul, 2005).

Elverdam and Aarseth (2007) identify two temporal metacategories, External Time and Internal Time, roughly corresponding to our real-world and gameworld temporal frames (some of their categories refer to the interaction between these frames). External Time has two categories, Teleology and Representation. Teleology is either finite (game ends at a specific time or after a specific duration) or infinite (game can go on forever). We handle this in our coordination frame, which explicitly deals with rule-based temporal subdivisions and limits. The Representation category can take on the value mimetic (time represented as flowing "the way time would pass in our physical world") or arbitrary (it is not). For us, time representation issues would primarily be addressed by the fictive frame (the various ontological categories in the fictive frame) and by analyzing interactions between gameworld, real-world, and fictive time. Elverdam and Aarseth's Internal Time identifies three categories: Haste, Synchronicity, and Interval Control. Haste corresponds to our category of Liveliness and Synchronicity to Turn taking. We have no single ontological category of Interval Control; however, these notions (do players determine when the next game cycle will commence?) are distributed over several ontological categories in coordination time. Our analysis of the "real-time" versus "turn-based" distinction (treated as the interaction between temporal frames) introduces the concepts of availability and immediacy, which are implicit in Elverdam and Aarseth's categories. Finally, two high-level differences in our approaches are our use of temporal frames as a unifying theoretical framework and our use of descriptive categories with central and peripheral members (strong and weak examples) rather than analytic dimensions that take on a small number of discrete values.

Tychsen and Hitchens (2009) focus on understanding temporality in multiplayer RPGs (paper and pencil, live action, computer based, and online). Their analysis builds on earlier work (Hitchens, 2006) and is informed by empirical studies of groups playing paper and pencil RPGs and NEVERWINTER NIGHTS (2002). Although we also develop our analytic categories in a bottom-up data-driven way, methodologically we differ in that, rather than developing categories to explain distinctions seen in a specific set of play sessions, we make use of our own play experiences, field notes of sessions of game-playing activity (e.g., Zagal & Bruckman, 2007), and documents associated with games, such as manuals, reviews, and screenshots (see Zagal et al., 2005). Each method has its own strengths and weaknesses. Our approach allows us to survey a larger range of games and temporal phenomena, while using detailed transcripts game playing situations can capture the fine details of player experience, particularly the perception of the passage of time.

Tychsen and Hitchens (2009) define seven temporal categories (what we would call temporal frames): playing time, engine time, server time, progress time, world time, and perceived time. Playing time defines the boundaries of play sessions in terms of real-world clock time. Our real-world frame accounts for the duration of play sessions but is broader because it also considers relationships between labeled real-world events and durations and other temporal frames. Engine time is defined as the chronological real-world time in which the game engine executes and is primarily used to define game sessions. Engine time and playing time are typically identical, although subtle differences can be found. For example, when a player saves a game, a break occurs in playing time but engine time continues. In terms of our definition of temporal frames, engine time does not seem to form a well-defined frame, because a specific set of events whose relations define engine time is not described. We could define engine time in terms of computational events allowing us to characterize phenomena such as slowdown. Server time is defined as the chronological real-world time during which the server operates. It can be useful to define analytic categories to account for the client/server distinction. However, server time is defined purely in terms of clock-time durations and thus does not constitute a full-fledged temporal frame. It could be defined in terms of computational and networking events taking place on the server. This would then provide a basis for explaining player-perceivable phenomena such as server lag or temporary inconsistencies in game state across players. Temporal frames defined by sets of events taking place in the underlying technology are most useful for describing "breakdowns"—situations in which technical issues break through into the player's experience.

The next three types of time, progress, story, and world time, are defined in terms of logical events related by temporal relationships (e.g., happens before, happens after), rather than chronological durations, and are thus most like our temporal frames. These times are nonlinear and can branch as a function of player action (e.g., loading a save point branches from a previous game state). We address such phenomena in our analysis of time as gameplay. Progress time defines progressions of the underlying mechanics and task progressions the player is trying to achieve. We include progressions of abstract gameplay actions as part of gameworld time. Gameworld time may also be broken out into multiple subframes, such as embedded or overlapping frames. Separating abstract gameplay events from events associated with a represented world is useful for certain kinds of analyses. In our framework, temporal frames can be defined as needed by isolating a subset of events and their relationships. The granularity of subset formation is a function of the kind of analysis desired, particularly in terms of relationships between frames. Story time is a subset of our fictive time, specifically the subset concerned with narrative progression. World time includes some elements of fictive time (such as turns in a game corresponding to the number of real-world days) and some elements of gameworld time (such as day-night cycles). We chose to separate these as fictive time explicitly leverages out-of-game temporal schema to establish a fictional world, while gameworld time is characterized by progressions and cycles that are self-sufficient within the gameworld.

Tyschen and Hitchens's (2009) final category, perceived time, is defined to stand in for the player's subjective perception of the passage of time. They found variations in player perceptions of gameworld events despite fairly concrete descriptions by the game master. Within their framework, all players have different event sequences, durations and relationships in their heads. We do not currently have a temporal frame that accounts for player perceptions across multiplayer games. We could interview players to find out their model of the event structure and then define player-specific frames in terms of these events. However, a predictive model of perceived time would be more satisfying. Nitsche (2007) argues that a divide exists between structuralist accounts of game time that analyze relationships between temporal frames and experiential accounts of time that describe the affective relationship to changing game state. Nitsche suggests that the relationship between perceived space and time may provide a useful framework for bridging this gap. Spatial design in games may be key for influencing the perception of time. In fact, architectural space is already understood as time dependent: A viewer cannot experience a building as a whole but, rather, builds a model based on a temporal progression of smaller spatial situations. This architectural dualism between time and space can be exploited for understanding player's perception of time.

Finally, Lainema (2008) examines time in business simulation games. Lainema is concerned that the majority of business games employ a batch-processing (turn-based) model in which participants make cyclic decisions in the context of a static game state. He worries that theories about the role of time in management and organization theory are underdeveloped, providing little leverage for moving beyond the batch-processing model. Lainema provides a theoretical framework for solving this. He identifies three temporal categories: mapping activities to time, analyzing the functional role of time, and analyzing dimensions of temporality. Activity mapping places activities on a timeline and focuses on single activity mapping (scheduling), repeated activity mapping (rhythm, cycles), single activity transformational mapping (qualitative transforms to the temporal process, such as increasing pace of events as a deadline looms), and multiple activity mapping (sequencing and overlap of heterogeneous activities). In terms of the temporal frames described in this article, activity mapping focuses on within-frame phenomena rather than phenomena across multiple temporal frames (other than simple durational relationships to the real-world frame). Of the within-frame phenomena described, single activity transformational mapping is not explicitly identified and can be usefully added to our framework. Similarly, the dimensions of temporality—sequencing, deadline, cycle, rhythm, duration, and temporal location—are primarily within-frame phenomena we account for in our framework. The functional role of time refers to whether time is seen as an independent or dependent variable, that is, whether it is viewed as something that affects organizational processes (e.g., time pressure effecting processes) or whether organizational processes influence the perception of time (such as variations in time horizon as a function of organizational location). This functional view of time cannot be fully accounted for in the current temporal frames model without fleshing out a cognitive frame.

Lainema (2008) argues that batch-based business games fail to account for the richness and variation described by these three organizational temporal classifications and that a move toward real-time business games is crucial for training that approximates the complexity of real-world decision situations. The temporal frames theory we present can provide guidance for business gaming in a number of ways. First, a temporal frames analysis shows the richness of phenomena that can be accounted for through complex relationships between frames. Although within-frame categories are necessary in providing the atomic relationships of temporal theories, it is the cross-frame analyses that provide theoretical richness. This could be harnessed through a temporal frames analysis of organizations, without reference to business games, and could provide a useful theoretical lens for analyzing time in organizations. All that is needed for defining a temporal frame is identifying a set of events and defining the relationships between those events. Thus, one could define a "sales" temporal frame in terms of events relevant to the sales department, a "research" frame associated with events in the R&D department, an "accounting" frame, and so on (frames do not necessarily have to line up with organizational departments). Analyzing relationships and temporal anomalies between these frames could shed light on organizational processes that within-frame analyses cannot capture. Second, by providing a more nuanced model of the turn-based versus real-time distinction in games, our model opens the design space for moving away from batch-based business simulation. Third, by accounting for a wide range of temporal phenomena in contemporary video games, we provide future business game designers with many design options for representing business processes in game form.

Conclusion

Multiple authors are converging on theories of game temporality that involve characterizing event relationships between multiple, simultaneous levels or frames. This indicates that this is a fruitful and productive approach to game temporality. A particular contribution of our article is an abstract, relationist characterization of temporal frames that supports analysts in creating new frames as they become useful in analysis and design. Much of what makes game temporality unique is the presence of multiple temporal frames and the interactions between them. Temporal frames allow the handling of disparate temporal phenomena under a unifying theoretical framework. Although theorists have introduced temporal categories similar to some of our specific temporal frames, this prior work has treated temporal categories as black boxes, defined once and for all, not viewed as instances of a more general concept. Our work provides a generalization of all event-based frameworks for analyzing game temporality. This framework supports the definition of new temporal frames as needed while performing analyses of specific games, highlighting the importance of analyzing the relationships between the different flows of time present in multiple temporal frames.

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