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SOCIAL DEMAND IN VIDEO GAMES AND THE SYNCHRONIZATION THEORY OF FLOW

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During video gameplay, our minds are a frenzy of activity. To succeed in these virtual environments, we must engage in a vast array of activities, such as visual-motor coordination, spatial reasoning, rapid decision making, and planning. Games simultaneously impose cognitive, emotional, behavioral, and social demands on players (Bowman, 2016); demands that require coordination and attention. Such demands can be overly challenging and frustrating, overly simple and boring, or as in the story of Goldilocks and the three bears, *just right*. In this *just right* phase of video gameplay, the challenge perfectly matches the player's ability. This balance of challenge and skill is held to facilitate flow, a state of mind in which attention is tightly focused on the task at hand, and which is experienced as pleasant (Csikszentmihalyi, 1990). These pleasant flow experiences are central to the reinforcing nature of gameplay, such that many people devote substantial time to it and sometimes sacrifice primary reinforcers such as food or sleep to continue playing.

According to the synchronization theory of flow (STF: Weber, Tamborini, Westcott-Baker, & Kantor, 2009), which focuses on the phenomenon flow during video gaming, flow experiences result from enhanced connectivity between large-scale networks involved in attention and reward. Support for this comes from neuroimaging studies that capture brain activity during video gameplay while manipulating the match between cognitive demands and the player's ability (Huskey, 2016). When playing at the "maximum level" of a player's individual skill (i.e., if the game was any harder, they would consistently lose), regions associated with attention, specifically controlled focus, synchronized with regions involved in reward processing. Following gameplay, players stated they had the most fun during the phases of enhanced connectivity between attention and reward networks, as predicted by STF.

Like most research on video games and flow, evidence for the STF comes mainly from studies that define challenge in terms of *visuo-motor task* demand, but neither research nor theory has closely considered how flow is affected by *social-task* demands. Modern video games increasingly include and capitalize on social interaction among players (e.g., multi-player online games, team-based shooters), which in some cases is a central part of the game itself. In such games, visuo-motor and social-task demands co-occur, and likely affect flow in a distinct way from games that feature visuo-motor tasks alone. For this reason, it is crucial to identify potential similarities between visuo-motor and social-task demands, and to demonstrate how these similarities extend our understanding of demand's role in determining synchrony and resulting enjoyment. Furthermore, to the extent that social-task demands differ from visuo-motor task demands, it is important to ascertain how these differences alter our understanding of the underlying mechanisms that determine how synchrony and flow emerge from these different demands. The current chapter outlines the synchronization theory of flow (Weber et al., 2009), its previous applications to the visuo-motor task demands of video games, and how it can be applied to examine the influence of social-task demands associated with video games in future research.

Synchronization Theory of Flow

The STF has its origins in Csikszentmihalyi's (1990) flow theory. In brief, flow refers to experiences characterized by a tightly focused attention to a task that balances the challenge of the task and one's germane skill, and an accompanying loss of one's sense of time. Originally, flow theory was developed to explain why artists and musicians often love their craft even in the absence of any extrinsic rewards. Researchers found that people most enjoyed performing when they were mentally absorbed in their chosen craft and were neither bored by (under-stimulated) nor anxious about (over-stimulated) the task. Csikszentmihalyi concluded that this so-called flow state is intrinsically rewarding in that it is enjoyable, exciting, and encourages well-being.

The STF expanded upon flow theory by applying a neurophysiological perspective to explain the phenomenon of flow. Specifically, Weber at al. (2009) conceptualized flow as an inherently pleasurable experience in which brain networks involved in attention and reward-related functions become synchronized during task performance. Synchronization is understood in terms of enhanced functional connectivity, an evaluation of the dependency of brain activity between different regions. The theory postulates that flow experiences result from the joint engagement of attentional and reward-related processes, which can be examined via functional neuroimaging.

Attention. As William James (1890) stated:

> Everyone knows what attention is. It is the taking possession by the mind, in clear and vivid form, of one out of what seem several simultaneously possible objects or trains of thought. Focalization, concentration, of consciousness are of its essence.
>
> (Cited by Evans, 1970, p. 74)

In this vein, everyone knows what attention is, and it is hard to imagine how we would navigate our daily life without this fundamental mental capacity to attend. Even so, getting a strong theoretical grip on the ubiquitous function of attention remains difficult, yet several taxonomies have attempted to add clarity to the concept (e.g., Chun, Golomb, & Turk-Browne, 2011; Posner, Inhoff, Friedrich, & Cohen, 1987). Perhaps the most prominent model divides attention into three functional categories: alerting (the ability to sustain focus and vigilance); orienting (the selective filtering of information); and executive attention (controlled and conscious processing, planning, and error detection; Posner & DiGirolamo, 1998; Posner et al., 1987). The neural systems that underlie these functions are distributed throughout the brain, and attention is best conceived as a networked process (cf. Rosenberg, Finn, Scheinost, Constable, & Chun, 2017). Key nodes of networks involved in executive attention—the most relevant type for focused gameplay—lie in prefrontal and parietal cortices, and activity in these regions increases when confronted with diverse cognitive demands (Cole & Schneider, 2007; Duncan, 2010; Seeley et al., 2007).

Critically for our arguments, the importance of attention to achieving a flow state has been demonstrated in a media context. Video games place high demands on attentional networks (Green & Bavelier, 2013), and diligent focus on these demands is critical while playing. For example, research has found that when video game players are distracted from the game's motor tasks, connectivity decreases in executive attention networks (Weber, Alicea, Huskey, & Mathiak, 2014). The authors interpret this as evidence that extreme disruptions to players' attention interrupted synchronization of activity in these networks.

Reward. Attention alone, however, is insufficient to achieve flow. Many cognitive battery tasks probe attentional functions, but none is particularly attractive or flow-inducing. Neither is proofreading a paper, washing windows, or playing the notoriously terrible *E.T.* game (1982; see Smith, 2015). It seems that flow requires reward-related processes to become simultaneously engaged with focused attention. Reward, like attention, is quite intuitive to grasp, but the psychological taxonomy and underlying neural basis of reward are more difficult to identify. In short, reward is something that both (a) produces positive emotions (pleasure) and (b) motivates behavior by reinforcing actions (Haber & Knutson, 2010).

Due to its fundamental role for motivated behavior, research on reward is dispersed across various topical domains, including addiction, sex, and food consumption (Kringelbach & Berridge, 2010), as well as playing video games (Huskey, 2016; Klasen, Weber, Kircher, Mathiak, & Mathiak, 2012). While we often speak of “a reward” or “a rewarding stimulus,” it is important to note that rewards are not inherent to things that exist in the environment: rather, rewarding functions are realized inside the brain. As such, although the contexts in which reward is studied differ on an experiment-to-experiment basis, the general principles of reinforcement are likely universal and rely on similar neural regions involved in reward processing. Scholars have determined a few somewhat separable subcomponents of reward (Kringelbach & Berridge, 2012), but reward is better thought of as a distributed and networked process that includes key reward nodes such as the *nucleus accumbens* in the ventral striatum and other regions (cf. Berridge & Kringelbach, 2015; Schultz, 2015).

The synchronization of attention and reward networks. According to the STF, flow states occur when attentional and reward networks become functionally connected or synchronized. When these networks are in disharmony, the mental effort needed to fully focus on an activity is immense. However, when a task is appropriately demanding to the performer, the attention and reward networks become more tightly coupled compared with a situation where task demands and skill level are incompatible. This balance of challenge and skill requires prolonged motivated effort to attend that taxes cognitive and affective processes. If the task were too difficult, players would have been overwhelmed to the point of tuning out—and even if they kept trying, the resulting experience could not be pleasurable. On the other hand, if the task were too easy, then it would not require enough attention to get excited. For example, consider a game that involves simple finger tapping, a relatively automatized motor routine that barely requires executive attention. To adults, this would likely be boring, as even though the task would require motor skill, it would not require executive attention. Conversely, to young children for whom even simple motor tasks require executive attention, the task may provide the match between skill and difficulty that is conducive to flow.

Weber and colleagues (2009) further argue that emerging system behavior during flow may be energetically efficient. They use the analogy of the Bak Sandpile Model (see Bak, Tang, & Wiesenfeld, 1987) to describe how this system behavior emerges. Imagine an hourglass. Once overturned, grains of sand continuously fall, and usually their effect on the resulting pile is minimal. Yet at some point, a small number of grains result in a cascading effect that sparks large-scale avalanching changes to the structure of the pile. The cascading effect might apply to the STF—relatively small changes to the synchronization of attention and reward neurons might lead to large-scale changes to the organization of the cognitive system and experiential correlates, in this case experienced as "flow." Weber et al. (2009) further posit that during states of enhanced connectivity (i.e., synchronization), task execution seems fluent and effortless, even if the task is challenging. As such, moments during which attention and reward networks synchronize may represent the discrete conscious experience of intrinsically motivated and inherently rewarding flow states.

The STF and Video Games

Video games are highly conducive to flow states for multiple reasons (see Chen, 2007). First, successful performance in a video game puts high demands on attention. Second, most games have alterable difficulty settings that allow a player to match his or her skill with the difficulty of the game. If a seasoned player is inured with a game they find too easy, s/he can turn the computer's skill level from "novice" to "master." When the criteria of intense focus and a balance of challenge and skill are met, synchronization of attention and reward networks is likely. Sherry (2004) noted these characteristics when he theorized that flow states during media exposure are enjoyable. He argued that similarly to other leisure activities originally studied by Csikszentmihalyi (1990; Csikszentmihalyi & Lefevre, 1989), video games offer a unique form of heightened sensory immersion that increases the likelihood of experiencing flow. Although Weber et al. (2009) highlight conceptual and operational problems in research examining self-reported flow during media engagement (see also Finneran & Zhang, 2002), studies indicate that engaging video games that balance challenge and skill produce flow-like experiences (Keller & Bless, 2008; Weibel & Wissmath, 2011). The STF suggests that these experiences occur because video games create optimal conditions for the synchronization of attention and reward networks.

Much of the empirical evidence supporting the STF and its central hypotheses related to attention and reward system activity stems from functional magnetic resonance imaging (fMRI) research measuring brain activity during video gameplay that predominantly tested players' visuo-motor skills. For example, a study that had players push a button as quickly as they could after seeing randomly inserted laser light flashes intended to distract them found that up to a point, functional connectivity rose within executive attention networks despite increasing levels of distraction (Weber et al., 2014). However, when distraction rose to a certain threshold, connectivity between regions of this attentional network was reduced (i.e., desynchronized). The authors concluded that below the threshold point, connectivity within attentional networks were robust and unperturbed by distractors. This is an indication of full attention on the source. Desynchronization occurred at the threshold, perhaps a marker of optimal attention. At this point, the light hindered a player's ability to focus on the game.

Other studies have tested the STF's hypotheses related to attention and reward network activity. A multi-experiment study collected behavioral, self-report, and fMRI data related to attention and reward during easy, hard, or user-tailored difficulty of gameplay (Huskey, 2016). In all cases, the player had to respond to random secondary tasks like those mentioned previously while playing. Slow reaction times to the task indicated full attention to the game. All data followed similar patterns; reaction times were slowest, self-reported flow was highest, and attention and reward networks were active and synchronized in moments of high attention when the game's challenge was tailored to a player's individual skill. Specifically, the cognitive control network, a network involved in executive attentional functions (Cole & Schneider, 2007; Seeley et al., 2007), was simultaneously engaged (i.e., synchronized) with reward-related regions. Similarly, increased attention and reward activation have been observed during moments of gameplay that reflect conceptual correlates of flow states (Klasen et al., 2012). During in-game conditions likely to hold a player's focus, visuo-motor attentional networks were most active, and regions associated with distractions were suppressed; the game was all that mattered. Concurrently, regions of the reward network activated when the game's challenge and player skill were likely balanced. These findings support the STF.

To date, all studies examining the STF have focused on visuo-motor tasks in video games as benchmarks for measuring the challenge and skill implicated in flow experiences. However, visuo-motor tasks are not the only type of cognitive demand placed upon players in games. We suggest that social aspects found in many games may produce a unique form of demand upon players that induce flow states. If flow states derived from motor- and social-task demands are identical, STF can be extended to include social tasks as facilitators of flow. Conversely, if motor- and social-task demands differ both in terms of the flow experience and the mechanisms associated with it, scholars could examine these differences and their unique outcomes.

The Unique Demands of Social Tasks

Humans are a social species and thus motivation and cognition linked to social interaction pervade almost all aspects of human life. In fact, playing social games is key to normal human development (Pellegrini, 2011; Power, 2000) and is omnipresent in all cultures. Accordingly, it is no surprise that social aspects are an integral part of many video games, where they demand considerable attention and may serve as a powerful source of reward.

Social affordances in games come with markedly different neurocognitive demands than visuo-motor tasks. To succeed in visuo-motor tasks found in games, people need to excel at translating complex visual information into accurate motor behaviors. However, to master a game's social tasks, people need to coordinate with others and engage in successful social interactions. These social demands include *perceiving*, *interpreting*, and *responding* to the various social signals that are central elements of modern-day multiplayer video games.

In addition to verbal communication, other cues for social perception include facial expressions, vocalics, and body movements, among others (Adolphs, 2009). To understand and act on this rich information, a particularly relevant skill is *mentalizing*, sometimes also referred to as *theory-of-mind processing* (Schaafsma, Pfaff, Spunt, & Adolphs, 2015). In brief, mentalizing involves simulations of other peoples' mental life to infer their thoughts, emotions, and intentions (Dunbar, 1998; Frith & Frith, 2006). Numerous studies document the human tendency to perceive social agency and attribute mental life to inanimate objects, ranging from the simple moving shapes studied by Heider and Simmel (1944) to the "characters" in modern animated films and video game avatars (Alcalá-López et al., 2017; Banks, 2015). Furthermore, literature has documented how people come to understand others' actions from observation, suggesting a link or loop between a sender's motor action and an observer's perception (Hasson & Frith, 2016). In sum, the social elements in video games recruit social-cognitive processes beyond those involved in visuo-motor tasks in single-player games (see Figure 10.1).

The field of social neuroscience has identified brain regions involved in these social-cognitive processes (Lieberman, 2007; Schilbach et al., 2013). Recently, researchers have made substantial progress toward identifying neurobiological mechanisms of face and voice perception (Belin, Zatorre, Lafaille, Ahad, & Pike, 2000; Kanwisher, McDermott, & Chun, 1997), two powerful cues for attracting and holding social attention (Kingstone, 2009; Klein, Shepherd, & Platt, 2009). Although the social brain remains far from understood, a large body of work has focused on the brain basis of mentalizing, which commands activity in the bilateral temporo-parietal junction, the precuneus, and medial prefrontal cortex (Lieberman, 2007; Schmälzle et al., 2017; Schurz, Radua Aichhorn, Richlan, & Perner, 2014). This *mentalizing network* overlaps with the so-called *default mode network*, which subserves crucial functions relevant for social cognition more broadly (Mar, 2011; Spreng & Andrews-Hanna, 2015). The regions of this network are distinct from those involved solely in motor

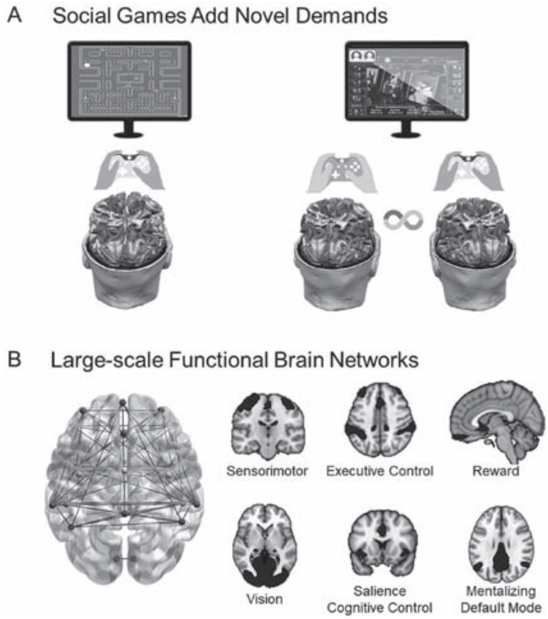

Figure 10.1 Your brain on video games—the neural networks involved in gaming.

Caption: Video games pose complex and dynamic demands on the human brain. (A) is an illustration of the single- and multiplayer gaming situation, and B) represents the task demands of video games that prompt coordinated responses across distributed brain systems. The left figure illustrates the networked nature of brain activity and the accompanying maps depict several large-scale brain networks that are likely to be engaged during game play. The synchronization theory of flow holds that flow occurs when networks related to attention and reward become synchronized. Social aspects of video games create distinct demands that can be met by recruiting brain systems dedicated to social processing, thereby offering added potential for flow-like experiences. The schematic brain network was created using BV BrainTutor (www.brainvoyager.com) and BrainNetViewer (Xia, Wang, & He, 2013), and the brain network maps are based on data from Yeo et al. (2011) and Choi, Yeo, and Buckner (2012), accessed via NeuroSynth (Yarkoni, Poldrack, Nichols, Van Essen, & Wager, 2011).

performance. In the context of video games, tasks that require interaction with social agents who exhibit appropriate social cues should engage this network, even if the agent is a nonhuman avatar.

The STF and social tasks. Despite STF research's focus on the attentional demands of motor behaviors, flow can be created via activities that require more than motor skills. Flow experiences generated during group activities require social skills that place high demands on attention and offer high reward. For example, team cooperation and communication have been found to influence flow experiences and performance during team-based competition (Aubé, Brunelle, & Rousseau, 2014). Specifically, teams that interacted more and experienced more flow performed better than others, suggesting that in interactive goal-oriented activities, failure to pay attention to social aspects leads to suboptimal performance. Thus, although motor skills and focus alone may be sufficient to produce flow during individual tasks, members of groups need to pay *social attention* to succeed.

Social task demands in multiplayer video games. The influence of social interaction on flow has been studied in many contexts, including musical performance and team sports (Csikszentmihalyi, 1975; Jackson & Marsh, 1996; O'Neill, 1999). Although some neuroscientists speculate that social interaction during video game play might facilitate flow (Harris, Vine, & Wilson, 2017), this proposition remains unexamined. The mechanisms through which flow arises during video games likely depend on game design, as different types of games require a different set of skills. Although the STF research focuses on the way motor skills in single-player games stimulate attentional activity necessary for flow, the theory can be extended to consider the influence of social skills in multiplayer games. Weber et al. (2009) define *skill* as "how accurately an individual's mental models represent embedded game rules and the mechanic of how toggles or keypads manipulate virtual environments" (p. 401). For example, a mental model for playing darts might feature the motor skills necessary to hit a bullseye as learned from prior behavior, whereas a mental model for speed dating might feature social skills learned through past successful or failed attempts to pitch woo. Similarly, *Tetris* (Various, 1984) requires hand-eye coordination and quick reaction, but for team-based games like *League of Legends* (Riot Games, 2009), social skills such as those related to mentalizing become more important.

In video games, mental models help players navigate the emotional and communicative elements of the game environment. For example, in single-player games with dynamic narratives, players' prior experiences—both in the real world and with similar games—will guide how they progress through the game and interact with game characters (Tamborini & Skalski, 2006). By similar logic, we speculate that in multiplayer games featuring other human players, past communication experiences guide how players interact with other human players to accomplish shared goals. Indeed, many games limit single-player achievements, requiring interaction and coordination among multiple players to overcome game challenges. Appropriate mental models of task-related social interactions are needed to succeed. Importantly, these mental models are not static; they are activated dynamically and continuously adapt as the game unfolds. A player must constantly assess where teammates are, the knowledge they possess, and their specific skill sets. Using this information, players must then determine the appropriate next steps to coordinate and accomplish the team's common goal. Ineffective inter-player communication would make successful gameplay impossible, and quickly terminate attentional activity necessary for flow. Thus, we suggest that the attention mandated by social interaction might result in a rewarding experience, producing flow via the mechanisms detailed by the STF.

The unique attentional demands of multiplayer games. When completing single-player games that emphasize motor skills and muscle memory, cognitive skills such as hand-eye coordination and targeting ability are sufficient to succeed (Bowman, Weber, Tamborini, & Sherry, 2013; Huskey, 2016). Conversely, in multiplayer games, social tasks engage regions associated with the awareness of cues to participate in joint interaction that are central to shared attention, such as a gesture to an object (Tylén, Allen, Hunter, Roepstorff, & Vogeley, 2012). Attention to these cues enables the accurate perspective-taking that is needed to understand others, thereby promoting successful interaction and regulation of the social structures that emerge during the game. These demands are like those found in other group activities such as sports or music, often used to exemplify flow, and the social skills needed to win in multiplayer games may be as important to eliciting flow as the capacity to control a ball or an instrument (Aubé et al., 2014; Walker, 2008).

Multiplayer games require various social skills from players that revolve around the ability to infer and understand other human player's actions. Specifically, players' ability to dynamically react to in-game challenges and each other's responses to these challenges are crucial to successful cooperation (Williams & Kirschner, 2012). Such social skills require significant attentional focus in multiplayer games (Kim, Oh, & Lee, 2005). This research examining whether the challenges associated with social interaction in multiplayer games leads to flow indicated that interactions with other human players predicted more attention to gameplay than interacting with the game's interface or coping with system performance.

If the forms of social task-related attention found in multiplayer games are distinct from single-player games, then multiplayer games might induce unique forms of synchronization unexamined by STF to date. Available evidence suggests that attention to social tasks produces success in multiplayer games that players find rewarding. Kim et al. (2005) demonstrated that attention resulting from social interaction predicted success and flow, and Kahn and Williams (2016) illustrated that coordination between teammates who understood each other's intentions (i.e., mentalized more accurately) won more. This association of attention to social aspects and rewarding results coincides with the key elements of the STF. Although these studies illustrate that attention to social tasks leads to the extrinsic reward of winning, the STF would predict that flow would result from the intrinsic reward expressed by an optimal match between social demands posed by these games and a player's social capabilities and communication skills. This experience is comparable to a party where people are immersed in smooth, interesting conversations, and take pleasure from these social interactions.

The rewards of social tasks and their implications for multiplayer games. Due to their fundamental relevance for humans as social beings, social activities are intimately interwoven with reward networks in the brain (Feldman, 2017; Harlow, Dodsworth, & Harlow, 1965). For example, being smiled at is intrinsically rewarding and affiliation is a basic human need (Lieberman, 2013; Panksepp, 1998). Although we expect that the social tasks found in multiplayer games produce more paths to reward than visuo-motor tasks found in single-player games, we expect no difference in how reward-related networks become engaged. Certain "hedonic hotspots" (cf. Kringelbach & Berridge, 2012) become engaged during social interactions associated with both appetitive and consummatory behaviors. Based on observations that the behaviors of perceived agents sparked appetitive reward network activity, scholars have concluded that social cues are interpretable as invitations to rewarding social interactions (Kampe, Frith, Raymond, & Frith, 2001). Related research demonstrates that positive social feedback, such as seeing a smiling face, is neurologically comparable with most well-known consummatory rewards, such as acquiring money (Izuma et al., 2008; Spreckelmeyer et al., 2009).

This research illustrates that social tasks can prompt brain activity in reward-related regions. Although it remains unclear whether social tasks differ from visuo-motor tasks with respect to the strength or motivation to pursue these rewards, some evidence suggests that this may be the case. First, social information possesses an especially powerful ability to grab and hold attention (e.g., Kingstone, 2009); second, social tasks might be rewarding in multiple ways; and third, the easily terminated nature of social-task rewards might command more diligent player attention to social behaviors than in single-player tasks. For instance, when media are consumed alone, the consumption experience is altered by breaks in attention. However, the medium itself—the book, movie, or song—is not altered by these breaks. In a single-player game, external distractions might break attention and momentarily affect the gameplay experience, but these distractions do not alter the player's ability to master the game and experience competence-related rewards. It might bother someone if their neighbor's dog is barking while that person is playing *Super Mario Bros.* (Nintendo, 1985), but the Mushroom Kingdom will not change, the princess will still be in another castle, and the player can still defeat Bowser at the end (regardless of whether you are distracted). As such, when consumers allow their attention to wander in single-player games, the risk of forfeiting reward is relatively low.

By contrast, in multiplayer games, the consumption experience and the activity itself are altered by breaks to attention, thus increasing motivation to diligently focus. Because the social rewards stemming from coordinated behavior may be particularly strong, any distraction that might prevent obtaining those rewards may be very costly. Failure to attend in a multiplayer game will not only reduce competence-related rewards (as coordination is necessary to win), but also irreversibly diminish rewards derived from social interaction. Unlike competence-related rewards stemming from visuo-motor tasks, rewards from social interaction must be achieved in real-time, not the game's time. If one player stops playing, the game does not pause for the rest of the team, and the entire team misses out on reward. The person who stopped playing is eliminated from all potential rewards simply by not playing. As the loss of this player makes gameplay more difficult for the remaining players, they suffer loss of competence-related rewards and risk a blow to social status. Even if the player returns, s/he may be blamed, shamed, and ostracized, greatly damaging the potential rewards of social interaction. Such social sanctions—or even the threat of social sanctions—might explain why multiplayer gamers take a considerable amount of time ensuring teammates are ready before a long battle, and will even take breaks before entering combat if players need to eat or use the restroom to relieve themselves (Ducheneaut, Yee, Nickell, & Moore, 2006; Williams & Kirschner, 2012). These players indicate that social interaction is a primary motivation to spend long hours playing (Chen, Duh, Phuah, & Lam, 2006; Cole & Griffiths, 2007; Yee, 2006) and consider attention to social interaction a crucial determinant of successful play (Kahn & Williams, 2016). In sum, there may be more motivation to attend to social tasks because there is considerably *more at stake* if one fails to diligently focus while playing a multiplayer game. Such diligent focus to social tasks might produce the neural synchronization detailed in the STF.

Conclusion

Research on flow has attracted considerable attention among video game researchers since Sherry (2004) first introduced the concept to the field. Early research focused on the balance between challenge and skill, and the STF added a neuroscientific perspective arguing that the intrinsically motivating experience of flow results from coordinated recruitment of brain networks involved in attention and reward. Evidence supporting the STF comes mainly from studies of video games taxing fine motor skills, but research to date has failed to consider how social-task demands in games affect flow experiences.

The commercial video game market is flooded with multiplayer games. The genre's success indicates that social games are attractive to players. Social-task demands thus likely play an important and potentially distinct role in experiencing flow during gameplay. As such, examining how *social-task demands* versus *visuo-motor task demands* engage brain networks related to attention and reward presents a promising avenue for research. Researchers should explore (a) if patterns of activity in attentional and/or mentalizing networks arising during multiplayer gameplay might oscillate with reward systems to produce forms of synchronization previously unexamined; (b) if such synchronization is experienced as "flow" or a different state associated with reward and positive affect; and (c) whether synchronization of neural networks related specifically to visuo-motor tasks as opposed to social tasks is associated with different intuitive needs (e.g., competence versus relatedness). Insights gained through such work will improve our understanding of the mechanisms that make video games challenging, absorbing, and generally fun to play.

Ludography

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