MIND, BRAIN, AND EDUCATION

The Influence of Social Contagion Within Education: A Motivational Perspective

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ABSTRACT— This article provides an overview of research on social contagion in the context of education. We highlight the importance of students' social interactions in school, considering contagion between peers and contagion from teachers to students, using a motivation perspective. The framework of contagion is introduced broadly, followed by a focused review on social contagion in school environments, both peer and teacher related. Then we introduce methodology for mapping behavior change to networks that are a direct representation of school cohorts. We argue that these different lines of research can be coherently interpreted from a motivation perspective, suggesting the critical role of motivation in social contagion, in the context of education. We highlight the limited amount of research on positive contagion effects and we call for further investigation into ways in which to increase the contagion of positive, academic behaviors. Finally, the neuroscience behind social contagion, both for the mechanisms and the interactions, is discussed.

Yawning, laughing, and smiling … all examples of behaviors that pass from one individual to another. However, consider the behaviors more specific to a classroom environment—are these also contagious? Imagine a friendship group of students in which one individual has a high interest in science—does their interest have the power to spark interest in the rest of their social group? Social

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contagion is an important psychological process that argues that it does.

In fact, since the 1800s, the term *contagion* has been used to describe many social actions, ranging from social and behavioral to criminal and hysterical. Described as the involuntary "catching" of behaviors and attitudes across connected individuals (Levy & Nail, 1993), social contagion has also become a well-accepted phenomenon in the psychology literature. However, at present, there is limited research on social contagion in the context of education. This is surprising, because in education it cannot be denied that certain children, no matter their age, have the natural ability to influence the moods and behaviors of their fellow students, without showing an explicit intention of doing so. While this may be a universal observation by teaching professionals, contagion is also present between teachers and students. The purpose of this article is to review the relevant literature on social contagion in the context of education, and discuss its application to the field of mind, brain, and education.

Another purpose of this article is to discuss social contagion in education from a motivational perspective. One of the potential limitations of the previous studies, which documented social contagion effects, is that they are relatively mute about the psychological mechanisms. On the other hand, psychological research on motivation has long indicated the importance of social relationships in students' motivated behavior. These lines of work suggest that many, if not all, of the social contagion phenomena observed in education could be explained by motivational mechanisms. In this article, we will attempt to discuss a variety of social contagion phenomena in education from a motivational perspective, with the aim to provide an integrated view on these segregated studies.

In the following, we first discuss the framework for social contagion. Next, we discuss a wide range of literature that suggests the prevalence of social contagion in educational settings, while mentioning the advancing methods for examining social networks and patterns of influence. We will then

introduce a motivational perspective on social contagion and discuss how the social contagion phenomena reviewed earlier can be explained by the motivational view. In the closing sections, we will discuss future directions and recent contributions to the topic of social contagion in education from the social network and social neuroscience fields.

FRAMEWORK FOR SOCIAL CONTAGION

In contagion literature, the focus lies on the influence of one individual on another, and the spread of influence in their friendship (or social) network. In more recent literature (especially in the emerging field of network science; Barabasi, 2002), a social network is often described in terms of "nodes" and "ties"; each person in the network existing as an individual node, and each person they name, or by whom they are named as a friend, is described as a tie. Therefore, nodes that are linked by a tie are assumed to be connected by friendship, which may or may not be reciprocated.

Specifically, a contagion effect is observed over time, and is characterized by similarity that is driven by influence and transmitted through a friendship tie (Ryan, 2001). Importantly, a mere similarity between connected individuals does not always mean that contagion has occurred. Rather, there can be two possible explanations: similarity due to contagion or similarity due to homophily. Social contagion suggests that the tie between individuals is the driving force for any convergence in behavior, attitudes, or personality. However, homophily suggests that individuals with similar interests connect and spend initial time together more often than those with dissimilar interests (McPherson, Smith-Lovin, & Cook, 2001). Therefore, the two processes seem to mirror each other: similarity in social contagion is driven by the tie, whereas for homophily similarity drives the tie formation. When friends are similar, contagion and homophily processes may be acting together or independently, and these processes should be evaluated separately when investigating contagion effects. Furthermore, it should be noted that many different terms are used to describe this contagion versus homophily effect, and in modern literature the distinction is most often described as selection (i.e., homophily) and influence or socialization (i.e., contagion). The terms are used interchangeably throughout this review; that is, contagion and homophily or selection and influence.

The seminal study by Kandel (1978) used longitudinal friendship pair data to study similarities between friends, addressing whether observed similarities are a product of homophily or contagion. Through a set of systematic analyses of the longitudinal data, this study identified that both homophily, followed by contagion, contribute to the similarities between friends. This work is among the first to highlight the importance of separating the mechanisms driving peer similarities. Since this seminal work, social contagion has been recognized as a universal phenomenon which can be observed in many different social populations and domains, going far beyond that of adolescent research—for example, contagion in the workplace (Welsch, 2016; Bakker, 2009), and contagion via social media (Guadagno, Rempala, Murphy, & Okdie, 2013; Lerman & Ghosh, 2010).

SOCIAL CONTAGION IN EDUCATION

Although social contagion is studied in a broad range of fields, we now draw special attention to contagion in friendships during adolescence, and the impact of selection and influence on child and adolescent behaviors at school. Numerous studies have investigated the role of homophily and contagion on a range of topics including adolescent depressive symptoms (Giletta et al., 2011; Prinstein, 2007); adolescent alcohol use (Burk, Van Der Vorst, Kerr, & Stattin, 2012; Popp, Laursen, Kerr, Stattin, & Burk, 2008); dynamics of religion in friendship (Cheadle & Schwadel, 2012); interest similarities (Fink & Wild, 1995); and similarities in perceived self-regulated learning (Jones, Alexander, & Estell, 2010)—in sum, demonstrating the importance of contagion during school and throughout adolescence, having implications for behavior and attitudes that will follow into adulthood. At present, there are limited articles that specifically and directly focus on social contagion in the school context. However, there is a large body of work focusing on peer influence, closely linked to the concept of contagion among students. There is also emerging evidence on contagion between teacher and student, and between teachers, including from senior staff to teachers. These studies can be considered as different manifestations under the umbrella of social contagion.

Negative Peer Influence

The term peer influence, different to our description of influence in terms of contagion or socialization, refers to the concept that people shift their opinions, attitudes, and behaviors based on those of the people with whom they are closely associated (Moody, 2001). While social (or peer) contagion is a term reflecting more general peer processes, without the implication of pressure to conform to a behavior, peer influence or pressure may imply that people are coerced into behaviors (Dishion & Dodge, 2005). In other words, peer influence can be regarded as a special aspect of social contagion. Perhaps because of this negative connotation, studies of peer influence have mainly focused on a variety of negative adolescent behaviors, including smoking, drinking, and substance use as risk behaviors outside of the classroom (for a full review, see Brechwald & Prinstein, 2011). These studies indicate the power of peer influence in increasing

negative risk behaviors, along with increasing delinquency among school age cohorts.

However, these investigations rarely consider friend selection when evaluating the strength of influence, meaning the research cannot statistically distinguish homophily from contagion. Despite this, the research can inform educators on the general impact of peer influence on academic behaviors and consequently has become a well investigated area of study.

In a unique experimental design, Cohen and Prinstein (2006) used a novel computerized "chat room" to research adolescent male conformity to negative health risk behaviors. During the study, 11th-grade (16–17 years) participants believed that they were in conversation with the three best friends they had nominated prior to the experiment. In reality, the participant was viewing the responses of e-confederates, whose answers were experimentally manipulated. The researchers found that high peer status led to greater levels of conformity to health risk behaviors, with social anxiety also moderating the level of conformity; those who were most anxious conformed regardless of peer status. These results demonstrate experimentally that peer influence can be simulated in online experimental settings, also demonstrating how personality types mediate peer contagion.

It should be noted that not all research conceptualizes peer influence with a coercive nature; rather, some research examines more naturalistic situations where peer effects are subconsciously working, more in line with the current conceptualization of social influence. For example, Zimmerman (2003) has examined peer effects in a controlled environment, taking advantage of the new living arrangements of students entering college. Using random room assignment, the assumption was that similarities in roommates' grades at a later point would provide a strong argument for peer influence naturally occurring between the roommates, impacting on their grade outcomes. Zimmerman found that, although the overall effects were relatively small, negative peer effects were present and were more strongly linked to verbal SAT scores than to math SAT scores. For example, the data suggested that those who had average GPA were likely to drop in performance when they shared a room with someone in the bottom 15% of the verbal SAT distribution (see also Sacerdote, 2001).

Along a similar line of thought, research on social influence also examined the effects of the quality of social relationship on academic outcomes. Wentzel and Caldwell (1997), for example, investigated the influence of friendships, peer acceptance, and group affiliation on academic achievement for sixth-year students. To measure friendship, students were asked to nominate three friends, and to measure peer acceptance, researchers measured each student's favorability for spending time with another (see Asher & Dodge, 1986). The results showed that the number of reciprocated friendships, peer acceptance, and group membership all contributed to predicting GPA, and make a case for the critical role of peers in facilitating students' academic performance.

In sum, the aforementioned research demonstrates the role of peer influence in social adjustment, academic adjustment, and achievement across a wide age range of students and settings. These findings support the idea that students are affected by their peers during adolescence (often influenced more than by their parents; see Harris, 2011), and shows why examining peer contagion might be valuable to educators (Sacerdote, 2011). However, much of the peer influence research considers negative and/or risk behaviors (for exceptions, Berndt & Keefe, 1995; Woo, Kwak, Lim, & Kim, 2014).

Teacher Contagion

The contagion effect observed between teachers and students may not be led by the same mechanisms as peer influence, but nevertheless can be considered as another manifestation of social contagion in education. From day-to-day observation of a learning environment, it is possible to see that the behavior of teachers has the power to influence that of the students they are teaching. Christophel (1990) noted that immediacy behaviors of teachers modify the motivation of students to learn. Furthermore, the well-known "Dr. Fox Effect" also shows how teachers' influence students, demonstrating that lectures performed with more enthusiasm result in better test results (Ware & Williams, 1975).

Literature on teacher contagion highlights the impact of increasing stress on teachers and the passing of this stress, or other emotions, onto their students. In a study examining the link between classroom teacher burnout and morning cortisol levels in elementary school children, Oberle and Schonert-Reichl (2016) measured salivary cortisol levels of students to assess the relationship between student stress and teacher burnout levels. The results revealed that students had higher morning cortisol levels if their teacher reported a high level of burnout, consistent with the idea of stress contagion proposed in social psychology (Huang, Wang, Wu, & You, 2016; Wethington, 2000). If stress contagion can pass from teacher to student, it is also reasonable to suggest that teachers may be "catching" the stress from more senior staff. Indeed, Westman and Etzion (1999) identified a crossover effect of job-induced tension between school principals and teachers, describing how stress in the workplace can jump between employees and elevate the stress of all staff.

However, research on teacher contagion has not only focused on stress. For example, Radel, Sarrazin, Legrain,

and Wild (2010) examined how the motivation orientation of teachers translates to the motivation of students using experimental manipulation. They delivered lessons to separate classes, one where students believed that the teacher was motivated by an extrinsic monetary incentive, and another where the students believed that the teacher had volunteered, being intrinsically motivated to lead the class. Despite the teaching content being identical, those taught by the paid teacher reported lower interest and less engagement, compared to students taught by the volunteer teacher. Furthermore, in a follow-up experiment, the same pattern of interest and engagement was shown when new, naïve students were taught by the student learners who were originally taught by the paid teacher. Findings such as these highlight the role of intrinsic motivation, the power of interpersonal cues about motives for teaching, and the power that unintentional motivational influence of teachers can have on students' learning.

Houser and Waldbuesser (2017) examined how teacher satisfaction and confirmation behaviors are related to their perceptions of students' nonverbal classroom behavior. The research showed that more highly expressive teachers are more likely to induce students to be more expressive, and therefore increase their level of nonverbal responsiveness. This study was based on ideas from emotion contagion theory (Hatfield, Cacioppo, & Rapson, 1993), arguing that confirmation behaviors of teachers has an emotional impact on students that is then reflected in the students' nonverbal responses. Such responses are fed back to the teacher, who will adjust their perceptions accordingly and continue to mirror and reinforce the felt emotion. In line with this idea, Mottet and Beebe (2000) found that teachers' emotional response and students' emotional response covary. With a large-scale longitudinal survey, Frenzel, Goetz, Lüdtke, Pekrun, and Sutton (2009) also found that teacher enjoyment influences their students' enjoyment over time, providing further evidence for teacher contagion in emotion and demonstrating the important role that social contagion plays in educational settings.

RECENT WORK WITH SOCIAL NETWORK METHODOLOGY

While the research reviewed thus far covers a wide range of methodologies examining different forms of contagion, we now focus on modern techniques employed in research on social networks. So far in this review, the statistical models and tests used in the majority of peer influence research are not able to statistically distinguish between the effects of homophily and contagion, as processes for group similarity. In recent years, however, more robust methods for analyzing network dynamics have emerged in the field of network

science and psychometrics, allowing the field to gain better understanding of the mechanisms that support social contagion. These methods are especially useful for assessing social networks in schools, and can enable us to assess the influence within classrooms and year groups.

Analysis of network dynamics originally emerged from the Framingham Heart Study, a longitudinal study with data that spans over 20 years, containing multiple waves of participants, linking many generations within a community. Using this mass data, Christakis and Fowler examined different network effects, such as spread of obesity, happiness, smoking habits, loneliness and divorce (Cacioppo, Fowler, & Christakis, 2009; Christakis & Fowler, 2007, 2008; Fowler & Christakis, 2008; McDermott, Fowler, & Christakis, 2013; Rosenquist, Murabito, Fowler, & Christakis, 2010). Since this foundational research, there has been much more focus on the impact of contagion in social networks (e.g., Aral, Muchnik, & Sundararajan, 2009).

Stochastic actor-based modeling (Snijders, Van de Bunt, & Steglich, 2010) is an example of a contemporary methodology that enables the prediction of network changes between discrete time points, longitudinally, accounting for the different mechanisms driving similarity. To date, only a handful of research has used stochastic actor-based modeling in educational settings, but the method is becoming increasingly popular due to its ability to separate selection effects from influence effects, through examining changes over time.

The strength of stochastic actor-based modeling lies in its flexibility and granularity to specify social influence and selection processes. Using the concept of "micro steps," the model accounts for multiple sequential changes that occurred between the time points when behavioral measures were taken. The model also accounts for the different types of similarity, distinguishing between homophily and contagion processes that often confound one another. Generally speaking, the model assumes that actors make decisions about changes to these ties at multiple time points (i.e., micro steps). The technique involves rigorous statistics, showing progression in the field by challenging other models, considering network and behavior as mutually dependent (Steglich, Snijders, & Pearson, 2010).

Indeed, there are clear benefits to using social network analysis in classroom environments. As reviewed earlier, there is clear suggestion that social contagion plays a critical role at school during adolescence (Berndt & Keefe, 1995; Wentzel & Caldwell, 1997); however most of the previous research used correlational techniques, making it difficult to disentangle selection from influence processes. Some studies used experimental approaches to test the causal effect of contagion (Cohen & Prinstein, 2006; Radel et al., 2010), but these studies disregard the potential role of homophily at school. In other words, these studies failed to take into

account the full information of the network dynamics to examine contagion processes.

Shin and Ryan (2014b) conducted one of the earliest examinations of selection and influence effects in early adolescence at school, by using stochastic actor-based modeling. They examined social network effects on achievement goals and academic adjustment. The sample included students aged 11–12 years, with data collected over two waves in the school year. Achievement goals were measured in three categories: mastery-approach goals (i.e., goals to develop one's competence), performance-approach goals (i.e., goals to do better than others), or performance-avoidance goals (i.e., goals not to do worse than others), and social network data were recorded by asking students to nominate their best friends. Overall, the model revealed different mechanisms for the different forms of achievement goal. Students tended to make friends with others that held similar mastery goals, increasing further in similarity between the two waves of data collection (i.e., influence/contagion). By contrast, those with performance avoidance goals did not tend to form friendship ties with similar goal-oriented individuals or tend to become more similar to friends over time. In addition, the students who held performance avoidance goals made many friendship nominations that were not reciprocated. This first study (Shin & Ryan, 2014b) provided new insights into the selection and influence processes driving the achievement goals of early adolescents.

Moreover, Shin and Ryan (2014a) also analyzed data based on other motivational variables (e.g., self-efficacy and intrinsic value) as a measure of academic adjustment. In this analysis, the selection results revealed a tendency for students to seek out friends with similar levels of self-efficacy and achievement, whereas influence was identified in effortful and disruptive behavior, and in students' levels of intrinsic value. Taken together, these results indicate that both selection and influence processes are involved in academic adjustment. Students are selecting their friends based on grades and confidence level (i.e., selection), with behavior becoming more similar as a result of those selections in either a positive or negative direction (i.e., influence).

In further investigation of academic functioning and peer contagion, Rambaran et al. (2016) designed a similar study in which they used stochastic actor-based modeling to identify selection and influence effects in academic functioning, specifically measuring grade point average (GPA) and truancy levels. The authors collected data on the social acceptance and popularity of students, along with GPA scores and number of unexplained absences from school. Selection effects were observed for achievement, while both selection and influence played an equal role in truancy. Furthermore, students had a tendency to become similar in both attendance and truancy over time, thus demonstrating a contagion effect. These results indicate that students have the power to influence positive as well as negative behaviors in their peers. Similarly, Gremmen, Dijkstra, Steglich, and Veenstra (2017) analyzed selection and influence effects based on achievement levels. After analyzing the longitudinal data, it was apparent that, at the first wave of data collection, selection (homophily) based on similar grades was the most prominent process. In the second wave, they found evidence that influence (contagion) drives grades to become similar over time, but only when there is evidence that the students have become better acquainted.

A MOTIVATIONAL PERSPECTIVE ON SOCIAL CONTAGION

So far, we have shown that social contagion occurs at many different levels in education. Research on peer influence has suggested delinquency behavior is transmitted between friends, while other research indicates that students' academic engagement and achievement seem to be influenced by their friends. Furthermore, social contagion is not limited to peer-to-peer relationships; often teacher's behaviors and emotions also have contagious effects on their students.

How does social contagion occur in the context of education? While social contagion has been documented in a wide range of literature, its underlying mechanisms are relatively underexplored. Some research has suggested that part of the contagion effect could be explained by mimicry. It is a human tendency to inherently mimic a range of actions from vocal accents (Adank, Stewart, Connell, & Wood, 2013) to physical mannerisms (The Chameleon Effect; Chartrand & Bargh, 1999). Other studies also indicated that emotional mimicry (e.g., Hess & Fischer, 2014), a term describing the imitation of emotion, has been tied closely to the theory of primitive emotional contagion (Hatfield, Bensman, Thornton, & Rapson, 2014; see also Hatfield et al., 1993). This mimicry and feedback process may operate at a conscious level, but research has shown that this process is more automatic and unconscious than people think (Chartrand & Lakin, 2013).

However, it is not probable that mimicry and feedback play a major role in the context of education. This mechanism is still an important source of social contagion in education, but in classrooms, where peers literally study together in the same space, social relationships tend to be extremely rich and dense. In such a situation, friends are likely to influence each other in a more explicit way. Indeed, it is difficult to explain some of the findings we have reviewed (e.g., social contagion of GPA) solely from a mimicry and feedback perspective.

Here, we argue that motivation plays an important role in social contagion in the context of education. Although the role of motivation in social contagion has been overlooked in the literature, several theories of motivation provide

some interesting and complementary perspectives of social contagion occurring in classrooms. For example, according to the social learning theory proposed by Albert Bandura (Bandura, 1986), a persons' motivation is grounded in the concept of self-efficacy, the personal judgment of one's own capability to achieve a task (Bandura, 1977). Importantly, Bandura (1977, 1986) argued that self-efficacy is formed through the socialization process, and identified several sources of self-efficacy; direct experience, vicarious experience, and verbal persuasion. In terms of social contagion, if a person has a high level of self-efficacy, this may contribute to convergence in behaviors between their friends. For example, think about the case we described at the outset of the article—where students' interest in science enhances their friends' interest in science. Based on social learning theory, if a student has a tie to a student who is highly competent and interested in science, his/her enthusiasm may spread through the tie via his/her verbal encouragement or explanation to the other student (i.e., verbal persuasion). Alternatively, the recipient of the tie may observe the success and enthusiasm of the friend and consequently begin to enjoy science vicariously (i.e., vicarious experience). It is also possible that the recipient of the tie has more opportunities to enjoy science as the friend is actively engaged in that subject. Consequently, those students with high levels of self-efficacy may have contagious effects on their friends in the classroom.

Some other theories of motivation also indicate the importance of social relationships in motivation. For example, self-determination theory (Deci, Vallerand, Pelletier, & Ryan, 1991) stipulates that people are naturally motivated to satisfy their need for relatedness—people's basic psychological need to feel supported and accepted by others, as well as a need for autonomy and competence. Indeed, this type of striving for relationships has been considered as the core component of human motivation (Baumeister & Leary, 1995; Wentzel, 1999). From this perspective, social contagion phenomena can be explained as students' motivated behavior to maintain social relationships. Even for the theories that originally did not incorporate social aspects—for example, theories of achievement goals (Murayama & Elliot, 2018) and causal attribution theory (Weiner, 1985)—recent developments acknowledge the social influence in these motivational constructs (e.g., Darnon, Dompnier, & Marijn Poortvliet, 2012; Juvonen & Weiner, 1993).

Indeed, this motivational account can easily explain the social contagion phenomena that we reviewed earlier. For example, social contagion of delinquent behavior may be a result of social learning—seeing your friend smoke may make you feel that you can do the same thing (i.e., increased self-efficacy to smoke). Or it is also possible that adolescents smoke because they are motivated to be affiliated with a particular peer group. Although the term "peer influence" implies some coercion, from our motivational perspective, this influence is also mediated by the motivation of those who receive the influence. Moreover, although this motivation perspective is acknowledged in the literature (especially in the work of peer influence; e.g., Akers, 2017), we suggest this as a more general framework to understand the educational social contagion phenomenon in a broader context.

To apply this framework further, social contagion of academic engagement and GPA can also be understood as a manifestation of social contagion of self-efficacy, because self-efficacy has been shown to be strongly related to these variables (Dogan, 2015; Komarraju & Nadler, 2013). In a similar manner, teacher contagion effects can also be considered as a version of social learning process—if students think that their teacher is feeling stressed and incompetent, students are likely to catch that feeling by inferring that they are learning something boring and difficult.

DISCUSSION

This review has introduced social contagion as an important consideration in education research. After describing the framework for socially contagious behaviors, we focused on the impact of social contagion between peers in education and introduced another form of contagion in the classroom, that between students and teachers. We have introduced new methodologies that now enable us to closely investigate the dynamics of friendship and social networks. These new methods are proving beneficial to education research as they can enable us to gain deeper insight into classroom activity and thus inform classroom interventions such as those focused on the development of social emotional learning and social emotional and academic learning (see Greenberg et al., 2003). Additionally, results from social contagion research may build our understanding of peer group learning (Parr & Townsend, 2002). Finally, we drew the research together from a motivation perspective, describing the underlying mechanism of social contagion. To conclude, we discuss two potential future directions for social contagion research.

Toward "Positive" Social Contagion Effects

Despite the growing interest in analyzing social networks in schools, there is scope for further investigations. Currently, the research described has been mainly focused on contagion of academic functioning and adjustment in school cohorts. However, since the investigation by Ryan (2001), there have been few studies that consider motivation as a driving force for academic contagion. Indeed, there are a number of motivational concepts that have attracted little

attention in the literature of social contagion (outlined in the previous section).

Furthermore, much of the aforementioned research in peer influence and adolescence is centered on reducing negative behaviors, as opposed to supporting the spread of positive behavior. Workum, Scholte, Cillessen, Lodder, and Giletta (2013) identified that the happiness of adolescents is influenced by the happiness level of their friends, so it is possible this may translate to behavior. Moreover, research on peer mentoring (where peer leaders volunteer their time to help fellow students) demonstrates that structured peer interaction can have a huge positive impact on both sides of a peer program partnership (Tredinnick, Menzies, & Van Ryt, 2015). Despite this, it is well established that teachers can identify any troublesome behavior in their class environment, and that certain behaviors cause more disruption than others (Wheldall & Merrett, 1988). However, the research has not yet provided comprehensive evidence to determine whether well socialized students may be having a positive impact on those around them in a natural, subconscious way (e.g., a well-motivated student facilitates motivation of other students via social contagion). Investigation of the strength of contagion for motivating positive behaviors is a natural next step in fully understanding social contagion.

Contributions From Neuroscience
An additional future direction to consider is the neurological basis of social contagion. Though direct research on the neural basis of social contagion is limited and relatively unexplored, there is increasing interest in the neural basis of social influence and conformity, and the value this can have in explaining real-world situations. In a review of neuroscience and social conformity (Stallen & Sanfey, 2015), the authors discuss mechanisms of conformity and their similarity to those seen in neuroscientific studies of reinforcement learning—for example, regions associated with conflict and reward expectation. Furthermore, in a recent meta-analysis of studies examining the neural components of social conformity, Wu, Luo, and Feng (2016) identified commonly reported regions related to reward and normative decision making, including ventral striatum, dorsal posterior medial frontal cortex, and anterior insula. In the context of contagion, though on a smaller scale, this research suggests an interesting possibility that reward processing and reward learning are the key mechanisms underlying social contagion (see also Suzuki, Jensen, Bossaerts, & O'Doherty, 2016).

There has also been intensive research on automatic mimicry or imitation in neuroscience (for a meta-analysis see Caspers, Zilles, Laird, & Eickhoff, 2010). This line of work has proliferated since the neuroscientific evidence that certain groups of neurons ("mirror neurons"), predominantly located in motor and somatosensory cortex,

fire spontaneously both when action is executed, and the same action is observed (Iacoboni, 2009; Pellegrino, Fadiga, Fogassi, Gallese, & Rizzolatti, 1992; Rizzolatti & Craighero, 2004). The findings are too diverse to summarize in a nutshell, but one of the key implications is that this line of work suggests the importance of "embodied cognition," emphasizing the role of motor and perceptual systems in the process of mimicry or imitation (Brass & Heyes, 2005; Gallese, 2009; Goldman & de Vignemont, 2009). So far, social contagion research in education has mostly relied upon self-reported questionnaires. However, this line of neuroscientific evidence indicates the importance of incorporating measures related to action and perception to comprehensively understand the nature of social contagion.

Another angle from which to look at the neural basis of contagion is to map the changes in the brain to the behavior of a social network. Recent research has explored how we create a cognitive and neural map of our social networks. In this way, the research is shifting emphasis from the mechanism behind the behavior convergence to the storage and maintenance of our personal social network formation (for a summary, see Falk & Bassett, 2017).

Parkinson, Kleinbaum, and Wheatley (2017) carried out an fMRI study in which a subset of individuals from a larger social network were presented videos of individuals from whom they had various degrees of separation and required to rate degree of separation. Analysis revealed that participants have accurate representation of the broad network of which they are a part, and are able to accurately perceive the positions, with spontaneous activation correlating with familiarity of individuals. Based on previous findings, the authors predicted that social distance would be signaled in the superior temporal cortex (STC), inferior parietal lobe (IPL), and medial prefrontal cortex (MPFC). This hypothesis was somewhat supported, with spontaneous activation found in lateral posterior STC through to the posterior lateral temporal cortex, moving superiorly to the IPL. Previous research has identified these areas as being associated with mental navigation, suggesting that the spontaneous activity is the result of retrieval of information from the spatial-construed, mental construction of the individuals' social network.

In other recent research Parkinson, Kleinbaum, and Wheatley (2018) used intersubject correlation analysis (Hasson, Nir, Levy, Fuhrmann, & Malach, 2004) to assess similarity in the brain activation between pairs of individuals while participants naturally watch movies. Results demonstrated that the distance between pairs in the overall social network could be accurately predicted based on the similarity in activation across multiple areas of cortex, between friendship pairs. Although correlational (i.e., contagion and homophily cannot be distinguished), these results suggest high levels of similarity between friends not just on a trait level, but also at the neurological level, demonstrating the

overall value of neuroscientific research in contributing to our knowledge of social contagion and the underlying processes.

CONCLUSION

For many years, educational researchers have demonstrated the importance of social processes at school. Indeed, a number of studies have shown that students' academic achievement, along with psychological and behavioral adjustments, are influenced by the classroom's social climate (Ames, 1992; Frenzel, Pekrun, & Goetz, 2007; Murayama & Elliot, 2009; Wentzel, 2000). Despite awareness of the critical role of social contagion in influencing classroom climate, these processes have attracted surprisingly little empirical attention in the field. The purpose of this review was to demonstrate the value of social contagion theory in developing the way we approach educational research. In the past, a lack of an appropriate methodological framework has limited the empirical investigation of these phenomena, but recent methodological advances have provided methods for researchers to make full use of the information in complex social network data. It is our hope that this review will provide inspiration for education and neuroscience researchers' alike, provoking interest in social contagion and motivation within the classroom, to provide further research evidence within this fruitful field of enquiry.

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