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REPLICABILITY AND MODELS OF PRIMING: WHAT A RESOURCE COMPUTATION FRAMEWORK CAN TELL US ABOUT EXPECTATIONS OF REPLICABILITY

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In this article, we argue that whether or not a replication attempt is informative is dependent on the accuracy of one's underlying model to explain the effect, as it is the explanatory model that enumerates the contingencies necessary for producing the effect. If the model is incorrect, then a researcher may unknowingly change variables that the model says are irrelevant but which are really essential, rendering the replication results ambiguous. The expectation that effects of priming on social behavior should be widely invariant makes sense only under the assumptions of strict direct expression and spreading activation models, yet it has been shown that these models cannot adequately explain findings from the priming literature. We describe one model of priming that predicts variability across experimental contexts and populations: *the resource computation model*. We highlight variables that have been uncovered under the assumptions of this model that cannot be accounted for by direct expression models and which can explain replication failures. The model is also consistent with evolutionary understandings of the mind, in which information from multiple sources beyond just stimulus information is incorporated into behavioral decisions. To the degree that anything other than a strict, direct expression, spreading activation model is correct, the expectation that priming of social behaviors should be widely invariant is unreasonable.

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A researcher publishes an intriguing priming effect showing that subliminal exposure to faces of black males increases participants' aggressiveness in response to provocation (Bargh, Chen, & Burrows, 1996). A second researcher decides to attempt a replication of this effect by repeating the original experiment. What are the appropriate expectations for the replicability of such effects of priming, and how does the model used to explain such effects influence these expectations?

In this article, we argue that the expectation that the effects of priming should be widely invariant (and, thus, easily replicable) is reasonable only if one holds a direct expression, non-motivational model of such effects.[1] Researchers holding such expectations tend to operate under spreading activation models found in cognitive psychology (e.g., Collins & Loftus, 1975). These models accurately describe some types of effects of priming (such as facilitated processing of semanticall—related words; Meyer & Schvaneveldt, 1971; Neely, 1977), and indeed these models were proposed in early work as a way to explain priming of more complex social and goal-directed behaviors (e.g., Bargh et al., 1996). However, more recent research (for a summary see Jonas, 2013) has demonstrated that spreading activation models alone cannot account for priming of social behaviors in all instances. Such models assume a single perceiver who encounters a social category stimulus in an environment devoid of other actors or objects, and with no desires or goals with respect to the target other—in short, a social, physical, and motivational landscape that offers little contextual richness in which behavior is entirely a function of stimulus features.

More recent models, in contrast, outline a large set of contingencies that would serve to reduce, eliminate, or reverse priming effects if not met. Such contingencies include whether the person likes or dislikes the primed category (Cesario, Plaks, & Higgins, 2006); whether a person has interdependent versus independent self-construal (Bry, Follenfant, & Meyer, 2008); whether a primed goal is associated with ingroup versus outgroup members (Loersch, Aarts, Payne, & Jefferis, 2008); or whether the prime is self- or other-generated (Mussweiler & Neumann, 2000). We describe one such model that outlines a set of contingencies, the resource computation model, and summarize recent evidence in support of it (see Loersch & Payne, 2011, 2014, this issue, for another such model). We conclude that the expectation that effects of priming should be consistent across a wide range of experimental contexts and populations is misguided, inconsistent with understandings of the evolved design of the mind, and should be reconsidered in light of more complete and accurate models of priming.

EXPECTATIONS OF REPLICABILITY

Every effect of priming has some set of contingencies that must be met in order for the effect to occur; that is, all priming is conditional (see also Bargh, 1989). One's theory or model for explaining a given effect of priming is fundamental precisely because it directs the researcher to those variables that are the key con-

1. Priming refers to a wide range of effects of the presentation of a stimulus, including everything from semantic priming (e.g., Neely, 1977; Posner & Snyder, 1975) to goal priming (e.g., Shantz & Latham, 2009). In this article, we refer exclusively to the effects of presenting social category members on automatic cognitive and behavioral responses. Such research is often referred to as social priming, goal priming, or automatic social behavior. Whether any of the arguments advanced herein apply to any other type of priming is unknown at this time.

tingencies necessary to produce the effect. Different theories will enumerate a different set of necessary contingencies (see also Asendorpf et al., 2013). Therefore, if a researcher is operating under an inaccurate model, he or she may be failing to take into account key variables. Indeed, the researcher may inadvertently change contingencies which are necessary to produce the effect but which are viewed as merely arbitrary or incidental.

To illustrate with the opening example, how might one's model for explaining the effects of priming *black male* influence which contingencies are seen as necessary and thus influence one's expectations of replicability? In the earliest work on priming social behaviors, such effects of priming were explained with *direct expression* models, which were essentially spreading activation models plus an unspecified link from cognition to behavior. Bargh and colleagues (Bargh & Chartrand, 1999; Bargh et al., 1996; Dijksterhuis & Bargh, 2001) explained their effects with the *perception-behavior link*, which enumerated the following three steps: 1) perception of the prime event caused activation of a corresponding mental representation; 2) activation of that representation spread to associated, stored information; and 3) information with increased activation was more likely to be executed when given the appropriate circumstance, due simply to its increased activation. Steps 1 and 2 are the traditional spreading activation model; step 3 is the vague link that "explains" why information with increased activation is more likely to be executed. For example, perception of subliminal pictures of young black males activates the mental representation of this category, activation spreads to associated information such as "aggressive," and the mere increase in activation of "aggressive" then makes it more likely that the person will behave in an aggressive way when provoked.

Suppose that such direct expression, spreading activation models are correct. Just like any other model, this model outlines a set of features that are necessary to produce the effect, and *as long as these contingencies are met*, it is reasonable to expect that the effect should be replicated. In the presence of repeated failures to produce the effect when meeting such contingencies, we rightly conclude that the original demonstration of the effect was likely Type I error.

What are the contingencies outlined by this and similar spreading activation models? The required contingencies are very straightforward and fairly easy to realize in any replication attempt. They include only: 1) the prime event itself (e.g., that people perceive subliminal pictures of young black males); 2) associations between the representation activated by the prime and the relevant stored information to be executed (e.g., that people associate black males with aggression); and 3) the appropriate circumstance to allow expression of the behavior (e.g., that people are provoked by an experimenter in a situation that allows for an aggressive response to be executed). Early research operating under such a model found that these contingencies did indeed influence the effects of priming, as when Dijksterhuis and colleagues found that the strength of association between the category *elderly* and the trait *forgetful* mediated the degree of memory impairment after priming of the category *elderly* (Dijksterhuis, Aarts, Bargh, & van Knippenberg, 2000).

It is easy to see why researchers operating under this kind of spreading activation model would expect priming effects to be widely replicable and why failed replication attempts would lead to the conclusion that the original demonstrations were Type I error. If one wants to replicate this effect, the required contingencies *as outlined by the model* are easy to achieve. For the first contingency, the prime event can be replicated exactly (as long as researchers are willing to share stimuli), and we know that changes to the prime stimuli or prime duration would change the expected effect (Higgins, 1996). For the second contingency, one can (and should) measure the association between the primed category and the measured trait through lexical decision tasks, output order, or other indirect measures, to ensure that participants do in fact have strong associations between, for example, black males and aggressiveness. Finally, it is a fairly straightforward matter to reproduce the appropriate circumstance by provoking the participant in the same manner as in the original demonstration.[2]

However, suppose spreading activation models are not the correct type of model to explain such effects of priming. In this case, the variables listed above might be necessary but not sufficient to produce the effect, as additional contingencies might also be needed. If this is the case, then a researcher seeking to replicate the effect may unintentionally change or lose necessary contingencies that he or she views as incidental or unimportant, thereby undermining or even reversing the priming effect. This may lead the researcher to erroneously conclude that the original effect was Type I error. Rather than that inference, the correct conclusion might simply have been that the researcher was operating under the wrong model, one that failed to identify the necessary contingencies to obtain the effect.

RESOURCE COMPUTATION MODEL OF AUTOMATICITY

Recently, we have proposed that automatic social behaviors following priming be understood as the output of a computational process that assesses what a person can and cannot accomplish in response to others (Cesario & Jonas, 2013). This computation includes an assessment of one's social, bodily, and structural resources, information that serves as input into decision processes concerning different courses of action. Social resources define what behaviors are possible and likely to be successful given the support of reliable others present. Bodily resources define what behaviors are possible and likely given one's current bodily states, including body position and physiology. Structural resources define what behaviors are possible and likely given the physical structure of the environment, including the presence or absence of action-relevant objects (Faber & Jonas, 2013). The computation involves integrating these features to lead to selection of one behavioral output over another (e.g., fight vs. flight, shoot or don't shoot, and so on).[3]

The model begins by proposing that perception of others (including perception from priming category members) initiates self-regulatory systems to prepare the body for effective interactions with the target other (Cesario, Plaks, & Higgins,

2. Even assuming a simple model, differences across broad segments of the population exist which may serve to undermine any one of the three required contingencies. The assumption that black males would prime aggressive behavior may not hold in societies in which the black stereotype is less clear, as in the Netherlands, for example, where one most likely would be able to replicate the effect with Arab faces (De Dreu et al., 2011).

3. We use the term computation as an indicator that such influences can and should be cognitively modeled. We (Cesario & Pleskac, in preparation) have recently begun a line of research modeling shoot/no shoot decisions in a first-person shooter task using a two-stage dynamic signal detection model, which models response times and error rates (see Pleskac & Busemeyer, 2010).

2006; Jonas & Sassenberg, 2006). In order for a person to effectively interact with others, decision calculations for such interactions must incorporate information about available resources for preparing and executing different behavioral response options. Only if such information is used as input into the decision-making process can behavior be regulated in an effective way. For example, human and nonhuman animal decisions about aggressive responses in contest situations follow game-theoretic logic and incorporate information about the presence of coalitional members (i.e., social resources). This is because such information changes the likelihood of successful aggressive actions and changes the costs that may be incurred by such behaviors (as costs can be distributed among group members if others are present; see, e.g., Benson-Amram et al., 2011; Fessler & Holbrook, 2013; McComb, Packer, & Pusey, 1994; Wilson, Britton, & Franks, 2002).

Importantly, this model of automatic behavior following priming is consistent with evolutionary accounts of the mind. The mind is not just similar to a computer, it is a computer in the sense that it is a computational organ: it takes informational inputs and regulates the body according to a set of evolved psychological adaptations (see Tooby & Cosmides, 2005). If the mind is to regulate the body with even the most remote bit of success, it must take into account information beyond just the information about the target other. In other words, stored knowledge about a social category member cannot be the sole determinant of behavioral output. Direct expression models of automatic behavior essentially argue that priming can be understood entirely as a function of activated stereotype content. In the case of behavior following priming of black males, this would mean that the brain had evolved to respond with aggression whenever aggression was perceived, regardless of one's coalition, whether one was lying prone or standing tall, or had objects for defense available. This cannot be the case, and such a model is inconsistent with what is known about nonhuman animal behavior (see Gawronski & Cesario, 2013).

Rather than behavior following priming being determined exclusively by the direct expression of primed stored content, a host of variables relevant to effective behavioral regulation combine to determine automatic responses to social category primes. Returning to the original point about replicability, a range of variables can be predicted to influence replication attempts *a priori*.

In what follows, we describe some recent experiments in support of the resource computation model, highlighting along the way how the model pointed to variables that should be important in producing certain effects of priming *given the model* but would have been regarded as irrelevant under other models (particularly non-motivational spreading activation models).

INITIAL FINDINGS SUPPORTING A SELF-REGULATORY ACCOUNT

In one of the first demonstrations that spreading activation models could not account for social behavior following priming, we modeled several experiments after the original Bargh and colleagues' (1996) findings, but with twists that pitted a direct expression, spreading activation account (as proposed by Bargh et al.) against a self-regulatory account (Cesario et al., 2006). First, we considered the study in which participants are subliminally primed with pictures of black males and are then provoked into an aggressive response. Instead of priming the black male category, however, we primed the category of *gay male* (vs. *straight male* or no prime). According to direct spreading activation accounts, priming *gay male* should result in decreased hostility, as the stereotype of gay males contains, almost universally, the stereotype of femininity or passivity. On the other hand, if a self-regulatory response is being prepared, we would expect that priming a negatively evaluated outgroup male, such as *gay male* (all participants were heterosexual), should result in more negative and aggressive responses. Indeed, priming *gay male* resulted in greater aggressiveness following provocation than either priming *straight male* or a no-prime control condition. These results do not readily follow from a model that considers spreading activation of activated stereotype content to exclusively drive priming effects.

Next, we again took an earlier, classic finding and modified it to produce a study that was able to test contrasting predictions from self-regulatory versus spreading activation accounts (Cesario et al., 2006, Study 2). Here, we took Bargh and colleagues' (1996) study showing that priming of the elderly stereotype (vs. a no-prime control condition) resulted in people walking more slowly and asked whether such responses should vary by participants' attitudes toward the elderly. According to direct spreading activation accounts, as long as the stored content *slow* is associated with the category *elderly*, then priming this category should result in slow walking speed, regardless of one's liking or disliking of the elderly. From a self-regulatory perspective, on the other hand, attitude toward the target group is a variable of central importance, given that effective behavior is defined very differently for liked and disliked others. To the extent that participants had positive attitudes toward the elderly, we predicted and found that they walked more slowly following priming, as one slows down to maintain contact with a liked, slow other. On the other hand, to the extent that participants had negative attitudes toward the elderly, we predicted and found that they *walked more quikkly following elderly priming*, presumably as a way to distance themselves from the disliked, slow other. Importantly, the degree to which participants associated the elderly with slow walking did not vary as a function of whether they held positive or negative attitudes toward them.

This study is particularly instructive for questions about replicability, given that a clear moderator was identified (attitudes toward the elderly) that could eliminate or even reverse the priming effect in a given sample, depending on the sample-wide level of this variable. Considering the widespread attention afforded to a failure to replicate the original Bargh and colleagues' (1996) finding (Doyen, Klein, Pichon, & Cleeremans, 2012), the assessment of such a moderator, among others, could help illuminate why failures can occur. But under the assumptions of a direct, spreading activation model, the only conditions for the effect to be obtained would be: 1) participants are primed with the category; 2) participants associate the elderly with slow walking; and 3) participants are given an opportunity to walk. If these conditions are met, then the replication attempt should be successful—or else one concludes that the original demonstration was Type I error, as many critics were quick to do. But for the replication attempt to be informative, the relevant contingencies *must* be in place, and these contingencies are defined by the explanatory model to which one adheres. It is becoming increasingly clear that spreading activation models cannot account for priming social behaviors, and therefore the expectations of replicability *derived from such models* are also becoming increasingly untenable.

EVIDENCE SUPPORTING STRUCTURAL RESOURCES

While the above two studies provided support for a general self-regulatory account (as opposed to a direct expression, spreading activation model), in another series of studies we tested the specific resource contingencies outlined above (social, bodily, and structural).[4] We first studied the possibility that structural resources would change automatic cognitive responses following priming if the structure of the physical environment changed which behaviors could be executed in response to a social category prime (Cesario et al., 2010). Specifically, we asked whether the physical environment of a person when primed with an aggressive target would influence the nature of the response to the prime. Basing our predictions on nonhuman animal models of defensive threat behavior, we predicted that whether participants were in a physical environment that allowed versus restricted fleeing behavior would influence the behavior prepared in response to the prime of *young black male*. If young black males are seen by white undergraduates as threatening outgroup members, then a defensive response should be prepared during priming. However, if this response takes into account which behaviors can actually be executed given the physical environment, then those participants in an environment allowing for flight behavior should show escape-related preparation, whereas those in an environment preventing flight behavior should show fight-related preparation.

To test these predictions, in one of the studies presented we primed participants with pictures of either young black males or young white males and tested the automatic activation of fight- versus escape-related action semantics. We then assessed the degree to which participants associated black males with danger (using a variant of Fazio's sequential priming task; Fazio, Jackson, Dunton, & Williams, 1995), reasoning that participants would prepare a defensive threat response only to the degree that they associated black males with danger. Crucially, the entire experiment took place while participants were seated either in an enclosed, restrictive space (a sound-resistant booth) or in an open field. In other words, the current structural resources either allowed for escape-related behavior to be executed in response to the prime or not. Consistent with predictions, we found that the relative activation of fight- versus escape-related words differed as a function of whether participants were in the booth or the field *and* the degree to which participants associated blacks with danger. When participants were in the booth, the more they associated black males with danger, the greater the activation of fight-related words. In the open field, however, the more participants associated black males with danger, the more they showed increased activation of escape-related words.

In addition to the primary finding that the structural environment influences automatic responses to primes, a further moderator was obtained in that the effect was contingent on the degree of association between black males and danger. The latter would be predicted from a direct expression account, while the former could not. If a researcher is operating under such a model, it would appear entirely

4. We do not discuss here our research on bodily resources, given that the research on this resource is the least developed of the three types of resources (see Cesario & McDonald, 2013, for research on how bodily resources, such as physical posture, can be understood as an input into the calculation of what one can accomplish).

reasonable to change this feature of the experimental context without any loss to the expectation of replicability. Indeed, what is more likely is that this feature of the experimental setup would not even register as an important variable precisely because the model says that it should not matter in obtaining the effect.[5]

A similar contingency, one not explained by spreading activation models, is the absence or presence of response-relevant objects in the current environment. If we consider again the black priming–aggression effect, responses could also be driven by other objects present (or absent) that one might use in relation to the primed category. While a bike may facilitate a flight response, a baseball bat may facilitate a defensive aggression response. Further, and building on the relevance of context introduced before, it would be difficult for spreading activation models to account for the effects of present objects on varying responses to social category primes. While one's representation of a social category undoubtedly contains links with objects used regularly and stably by the category, objects used in relation to the category are variable across contexts and are dependent on one's current motivation toward the category, resisting simple associative links. For example, one might associate bats with black males due to a connection with athleticism (black males are good athletes and routinely use bats for this purpose), and one might associate wheelchairs with the elderly due to a connection with frailty (the elderly typically use wheelchairs for transport due to frailty of old age). Spreading activation models might well predict activation of bats or wheelchairs when priming black males or the elderly, respectively. But it would be quite a different matter for spreading activation models to predict that bicycles should be activated by black males to the extent that one associates black males with danger and bicycles being a good means to flee, or to predict that wheelchairs should only be activated in response to the elderly if one has the goal to transport the elderly, but not the goal to rehabilitate them. Moreover, the relevance of the object is only given through the situation; in a different situation, the same object could be rendered useless.

Initial evidence for such an object co-determined response comes from research by Faber and Jonas (2013). Within an eye-tracking paradigm, these authors showed that a social category prime in a matching context led to more attention for response-relevant means. For example, in a sequential priming paradigm, attention for cheering devices was higher only after priming athlete and a stadium context, compared to a shop context or for irrelevant objects. These data show that social categories in matching contexts also increase attention to response-relevant objects.

EVIDENCE SUPPORTING SOCIAL RESOURCES

In a recent line of research, we have begun to investigate the way in which the presence of ingroup members changes automatic responses following priming of social categories. Ingroups are important insofar as the presence of reliable coali-

5. This study also illustrates further complications with replication attempts and the difficulty of trying to reproduce exactly the situation of a prior experiment. For instance, we took great care to ensure that participants would not encounter other students during their participation in the experiment, the reason being that seeing other university students might constitute a social resource, and the presence of coalitions is known to influence the likelihood of escape versus fight behavior (e.g., see Benson-Amram et al., 2011). The next section on social resources details this logic in more depth.

tion members changes the range of responses available to a person. If behavior in response to social category primes is to be effective, it must take into account the presence of others—ingroups both increase the likelihood that certain actions can be successfully executed and distribute costs of risky actions across group members.

There is evidence from a wide range of social species showing that the presence of others is taken into the calculus of which of several behavioral responses to execute, especially when it comes to defensive threat regulation. One illustrative example involving wild hyenas is provided by Benson-Amram and colleagues (2011). These researchers played the sounds of stranger (i.e., outgroup) hyenas to wild hyenas through a concealed speaker and assessed whether a target hyena hearing the sounds would flee or approach. These researchers found that a strong predictor of this behavioral choice was numerical advantage: the ratio of the number of ingroup hyenas present to the number of outgroup hyena voices. The greater this ratio, the more likely hyenas were to approach the unknown outgroup voices. This influence of one's coalition (in this case, familiar ingroup hyenas) is consistent with a game theoretic perspective on animal conflict (Maynard Smith, 1979; Maynard Smith & Price, 1973), and it appears that hyenas were computing the relative strength of the ingroup and outgroup coalitions in making decisions about different courses of action.

Returning to the case of priming social categories, then, thepresence of one's coalition should affect the automatic responses to the social category, as the presence of the ingroup as a resource can change the potential costs incurred by risky actions and make certain behaviors more likely to be effective and successful.

We have so far studied responses to two different social categories and the ways in which being surrounded by other group members can influence the action tendencies automatically elicited in response to the primes (Cesario & Jonas, 2013). Across studies, our methodology has been similar: participants complete a task measuring automatic reactions to primes, but do so in the experimental room either alone or with a group of other ingroup members (with their shared ingroup identity made salient).

In a first study, we looked at how automatic responses to *police* primes changed depending on participants' currently available social resources. Specifically, we assessed reaction times in a lexical decision task to words related to *rioting* in response to police (or control) primes, while participants completed the task either alone or surrounded by an ingroup. Rioting is a behavioral response that can only be done with others; you cannot riot alone. We predicted and found that *police* primes led to increased accessibility of *riot*-related words only when participants were surrounded by others, not when they were alone. In other words, automatic cognitive processes took into account the social situation of the individual.

In a second set of studies (including two direct replications), we tested several predictions that follow from a resource computation account using a different kind of automatic reaction, that of whites' automatic evaluation of young black males. Physically formidable outgroup males would have been a recurrent evolutionary threat, and the mind likely evolved computational programs to assess coalitional numerosity (see, e.g., Kurzban, Tooby, & Cosmides, 2001; Navarrete, McDonald, Molina, & Sidanius, 2010). Therefore, physically formidable black males would, for whites, constitute an outgroup threat. Here, we tested the idea that (physically formidable) black males would no longer be automatically negatively evaluated when participants were surrounded by their racial ingroup, reflecting the fact that ingroup members change what strategic responses are deemed necessary in response to threat.

If the presence of one's coalition changes the computation of action possibility, then two predictions would follow. First, a physically formidable outgroup male requires vigilance and should be negatively evaluated when a person is alone (and therefore less able to incur the costs of aggression and less able to inflict costs on others; see also Cesario & Navarrete, 2014). Second, such vigilance and negativity should be attenuated when one is surrounded by one's coalition because one now has the resources to manage the threat. If automatic reactions from priming were indeed sensitive to the presence of social resources, then we should detect these changes in typical indirect measures of attitudes.

To test these predictions, participants completed two implicit association tests (IAT), either alone or surrounded by their ingroup. They completed both a stereotype IAT, which assesses the association between blacks and physicality (compared to whites and mentality), and an evaluative IAT, which assesses the association between blacks and negativity (compared to whites and positivity; see Amodio & Devine, 2006). We then examined the correlation between scores on each of these two measures, comparing this relationship between those participants who completed both measures alone and those who completed both measures surrounded by the ingroup. If the presence of others changes which responses a person computes as possible and effective in response to a potential threat, then the correlation between these two measures should depend on whether participants were alone or in the presence of the ingroup. Specifically, we found that when participants were alone, a positive correlation between responses on these two measures was obtained: the more black males were stereotyped as physical, the more they were negatively evaluated. However, we found that when participants were surrounded by their ingroups, this correlation was attenuated: A physically formidable outgroup male no longer carried the same negative evaluation.

Returning to the theme of the expectations for replicability, the resource computation model *predicts a priori* that the presence of others should matter for priming effects because automatic responses from priming are strategic and reflect functional preparation for interaction, at the cognitive level. In contrast, a direct expression or spreading activation model *predicts* that whether a participant is alone or surrounded by others should not matter in the least for priming effects, as priming effects are triggered merely by the presence of the appropriate stimulus (and not what actions are possible given the presence of others). Therefore, whether a researcher is a proponent of one model or the other directly influences expectations of replicability because each model describes for the researcher those variables that can be changed (or not changed) during a replication attempt.

CONCLUSION

What are the appropriate expectations for the replicability of the effects of priming? In this article, we have argued that one's model for explaining such effects directly and wholly informs such expectations, because the explanatory model enumerates the contingencies necessary for producing the effect in question. If direct expression, spreading activation models are correct in explaining these effects, then a certain set of contingencies are needed. These contingencies, which include the presence of the stimulus, association between the stimulus and the response in question, and the opportunity to execute the response, would naturally lead to the expectation of widespread invariance, given that such contingencies are very easy to implement in an experimental replication. In the presence of repeated unsuccessful replications of an effect of priming, one would rightly conclude that the original effect was likely Type I error.

To the extent that a spreading activation model is insufficient to explain the effects of priming, however, then one's expectations of invariance are unreasonable and unfounded. This is because the contingencies in place, which are believed to be necessary and sufficient for producing the effect, are in fact insufficient. Recent research has shown that spreading activation models cannot fully account for the effects of priming, and several more complex models have arisen in recent years, all of which enumerate a long list of additional contingencies necessary to produce such effects. We described one such model in the current article, the resource computation model. If correct, it suggests that a range of additional contingencies—beyond just those proposed by spreading activation models—must be in place in order to obtain effects of priming. This model is consistent with evolutionary understandings of the mind, in which information from multiple sources beyond just stimulus information is incorporated into behavioral decisions. The model directly undermines the expectation that effects of priming should be widely replicable across varying experimental contexts and populations.

We conclude on a final caveat. It is important to note that the argument outlined in this article should *not* be used as an excuse for poor research practices on the part of priming researchers, who might be publishing false findings due to a combination of researcher degrees of freedom, questionable research practices, and file drawer activity (see, e.g., Pashler, & Wagenmakers, 2012; Simmons, Nelson, & Simonsohn, 2011). While it may be tempting to explain away every failure in terms of unknown moderators, to do so would be to undermine the self-correcting nature of science. Moreover, priming researchers themselves have been insufficiently concerned with data reporting and collection practices and have contributed to the current state of confusion regarding the reliability of priming results. In other writings, we chart out a path for both priming researchers and critics to advance in a constructive way, and we provide recommendations for priming researchers to increase the quality of our research (see Cesario, 2014).

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