Mixed Signals and Crisis Bargaining:
A Game Theoretic Analysis of Deterrence
and Spiral Theories of International Conflict

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The change in the language and tenor of the letters from Khrushchev indicated confusion within the Soviet Union, but there was confusion among us as well. At that moment, not knowing exactly what to suggest, some recommended writing to Khrushchev and asking him to clarify his two letters. There was no clear course of action. Yet we realized that, as we sat there, the work was proceeding on the missile sites in Cuba, and we now had the additional consideration that if we destroyed these sites and began an invasion, the door was clearly open for the Soviet Union to take reciprocal action against Turkey (Kennedy 1969: 96).

Robert Kennedy’s *Thirteen Days*, a first-hand account of the confusion and stress of the Cuban missile crisis, is perhaps the most compelling of the many treatments of that crisis. The above passage from Kennedy’s book recounts the consternation of October 27, 1962, when President John F. Kennedy received two somewhat contradictory letters from Nikita Khrushchev, one apparently personally written by the Soviet premier, the other apparently authored by the Soviet Foreign Ministry. Robert Kennedy’s account of the administration’s confusion captures the uncertainty over the Soviet Union’s intentions; given the contradictory letters, what should the United States do? The administration’s response, well known as the “Trollope ploy,” is well documented elsewhere and needs little elaboration here. The essence of the ploy was that the United States agreed to Khrushchev’s proposals in his first letter while ignoring the second. The following Monday the two superpowers announced the resolution to the crisis on the basis of the terms the Soviet Premier proposed in his first communication.

The Trollope ploy is one of the more well-known instances of signaling between nation-states in a time of crisis. Beyond its historical significance, political scientists find it theoretically interesting for a number of reasons. First, perhaps on no other occasion were the stakes of an international crisis so high. Given these high stakes, the Cuban missile crisis presents an important test of two theories of international conflict, deterrence theory and spiral theory, that posit fundamentally different causes of wars. Deterrence theorists argue aggressive nation-states start wars, while spiral theorists emphasize how the security dilemma can give rise to spirals of fear and hostility among even pacific nation-states. Both emphasize, however, the importance of communication, either of credible threats or of pacific intentions. With so much at risk during the Cuban missile crisis, American policy makers implicitly relied upon the prescriptions of these two theories and upon their communications with the Soviet Union as they assessed whether or not the Soviet Union had hostile intentions. Second, the ploy is interesting because it was a response to seemingly contradictory signals from the Soviet Union. While Khrushchev’s first letter contained a solution that the Kennedy Administration found amenable, the second did not. This raises an interesting question: how did these mixed signals influence the United States’ assessment of the Soviet Union’s hostile intentions? Given the importance of communication in both the spiral and deterrence models of conflict, this example of miscommunication offers an opportunity to test the theories’ prescriptive implications. For these reasons, the high stakes and the important signals of the Cuban missile crisis offer a case study to intermediate between spiral and deterrence theories of international conflict.

This paper assesses the merits of the spiral and deterrence theories of conflict by modeling the denouement of the Cuban missile crisis as a signaling game. By adapting a signaling game developed by Cho and Kreps (1987), the paper assesses whether the prescriptions of deterrence theory or spiral
theory offer better outcomes. The first section of the paper discusses the points of agreement and disagreement in the deterrence and spiral theories of conflict. The second section then briefly discusses how members of the Kennedy Administration implicitly relied upon the spiral and deterrent models during the Cuban missile crisis. The third section argues that international relations theorists can model the missile crisis—or a wide variety of other crises—as a signaling game that incorporates the prescriptions of deterrence and spiral theories. Finally, in the fourth section the paper determines the perfect Bayesian equilibrium solution of the game, and discusses its implications for theories of conflicts. While the model uses the Cuban missile crisis as its case, the paper argues that the structure of the model is generic and analogous to a broad range of international crises and conflicts.

The paper concludes with a discussion of its two principal findings and their theoretical implications. In brief, the paper finds that when a nation-state is clear about its hostile intentions (or lack thereof), it receives higher payoffs than when it pursues a purely deterrent or purely tension-reducing strategy. This finding contradicts the prescriptions of both deterrence and spiral theorists, who advocate either indiscriminate threats or indiscriminate tension-reduction strategies. It provides, furthermore, a game-theoretic perspective on the importance of both barriers to accurate perceptions in international relations as well as the utility of transparent measures like arms control verification and issue linkage. Second, the paper demonstrates that this finding holds for all rank-ordered payoffs irrespective of their values provided the order of payoffs is preserved. Given this ordinal assumptions, the game demonstrates that the rational actor will never “bluff” (or in game theoretic terms, pursue a pooling strategy). Since both spiral and deterrence theories treat state types axiomatically and prescribe strategies irrespective of state types, these findings demonstrate the theoretical insufficiency of both the spiral and deterrence theories of international conflict. Both theories of conflict must endogenize state types; by treating state types axiomatically, their theoretical findings and prescriptions are tautologous.

1. Signals in the Spiral and Deterrence Theories of Conflicts

The spiral and deterrence theories of international conflict contain implicit assumptions about signaling between nations. The two models offer starkly different explanations for war and what nation-states should do to prevent it. The spiral model suggests that states are defensively oriented: they react to threats to their security. In this sense, states are fundamentally “doves.” The deterrence model by contrast explains conflict as the result of deliberate and aggressive state behavior; states therefore are “hawks.” The two models therefore posit two different types of states in international relations. These different assumptions about state types and motives reflect the broader disagreement between spiral and deterrence theorists about the origins of conflict and the role of threats in conflict processes.

The spiral model shares the neorealist assumption of an anarchic international system: because states alone must assure their survival, international relations is fundamentally the quest for power and security. According to the spiral model, international conflict is the consequence of states’ defensive reactions to each other’s policies under the security dilemma. Because states react to each other, the model emphasizes the process of conflictual relations: each state calculates its security interests and policies in response to the policies of another state. Conflict is the product of escalating cycles, or “spirals,” of fear and hostility between states. In this sense, the spiral model suggests that conflict may arise even when states are inherently defensive doves. Conflict can occur without deliberate aggression;
for instance, the spiral model explains World War I as a conflict none of the combatants intended. To avoid international conflicts, states must avoid actions that appear aggressive and will precipitate a cascade of actions and reactions. That is, states must communicate their defensive nature and demonstrate that they are doves, not hawks. They must send mollifying signals to ameliorate tensions rather than threatening ones that might precipitate spirals of hostility and distrust.

The deterrence model contrasts significantly with the spiral model. Deterrence is “discouraging the enemy from taking military action by posing for him a prospect of cost and risk outweighing his prospective gain” (Snyder 1988: 25). Whereas defense suggests the use of force during wartime against an enemy’s capability, the deterrence model prescribes the threat of the use of force during peacetime against an enemy’s intentions (Snyder 1988: 25–26). To prevent conflicts, therefore, states must send threatening signals, not the appeasing signals prescribed by spiral theory. These threats must be credible: a state must possess not only the capability to carry out deterrent threats, it must also have vital interests at stake for which it will risk a conflict. Threats that lack credibility will not prevent international conflict; in fact, they may encourage aggression because noncredible threats may signal a state’s weak position.

The strength of the deterrence model is its acknowledgment that, unlike in the spiral model, states may be offensively-oriented hawks. For this reason, the deterrence model explains how conflict can arise from deliberate state policies. The model captures a number of historical cases that the spiral model cannot: both Germany’s aggression prior to the Second World War and Iraq’s invasion of Kuwait in 1990 indicate the power of the deterrence model to explain important international conflicts. In this sense, the deterrence model’s focus on hawkish states is an important complement to the spiral model’s analysis of defensively oriented states.

Signaling behavior is important to deterrence theory because of an inherent contradiction in its logic. If a state is to make credible threats, then both its capabilities and interests must be apparent to a prospective enemy. In this sense the model treats capabilities and interests as objective referents for rational states. But if states can determine objectively the interests and capabilities of potential enemies, then no rational state would initiate a hostile act since it would know a priori that its opponent possessed an effective deterrent—or conversely, a state would not respond to aggression because it would know it would lose. In a world of rational states and objective capabilities and interests, conflict therefore cannot occur since states would be self-deterring. To resolve this theoretical problem, deterrence theorists have made both interests and capabilities endogenous to the model in order to explain the occurrence of conflict. States must communicate their interests and capabilities since they are no longer obvious, objective referents. This communication process therefore is vital to effective deterrence; a failure to signal a threat can explain the failure to deter.

Whether threatening or mollifying, these signals contain a paradox. Snyder and Diesing have argued that deterrent threats create a “credibility paradox:” as a state attempts to communicate its vital interests and its capabilities to back up its threat, it may in fact appear to be aggressive and bring about the conflict it sought to avoid (Snider and Diesing, 1977: 183–381). In this sense, the deterrence model risks a self-fulfilling prophesy. The obverse of the credibility paradox is that efforts to preserve peace may in fact encourage aggression from other states. Snyder’s insight demonstrates that threatening and
tension-reducing signals require a razor’s-edge balance of threats and moderation. Too much of either can produce conflict in a world of hawks and doves.

The spiral and deterrence models differ fundamentally over two questions: the role of threats of force, and the origins of conflict (Jervis 1976: 58–113; Reiter 1995). The spiral model sees threats of force as hastening conflicts: threats of force cause defensive states to react, further escalating the spiral of threats. In stark contrast the deterrence model sees threats of force as preventing conflict rather than precipitating it. Credible threats will encourage rational states to forgo hostile actions that would lead to conflict. Unlike the spiral model, wars result not from the interactive processes of states but from the aggressive intentions of individual states. Unfortunately, these contrasts of the two models offer policy makers little guidance: aggression either causes or prevents conflict, states are either defensive or offensive.

Since both models take state types as axiomatic, furthermore, deterrence and spiral theorists often talk past each other. The value of a signaling game is that it can endogenize state types and allow the researcher to test each theory’s hypothesized best strategy as a function of the probability that nature selects states as hawks or doves. Both theories posit that states rely upon communication to send either threatening signals or mollifying ones. States may choose to escalate conflicts or to prevent them. These strategies and signals are contingent, however, upon whether one’s opponent is a hawk or a dove. As is evident from Robert F. Kennedy’s lament during the Cuban missile crises, however, a state’s type is private information. Given this and the importance of communication in deterrence and spiral theories, a signaling game offers a means of intermediating the debate between deterrence and spiral theories of conflict.

2. Deterrence and Spirals During the Cuban Missile Crisis

As the recipients of Premier Khrushchev’s letters that proposed a resolution to the missile crisis, President Kennedy and his advisors held beliefs and formed opinions about the nature of the crisis that illustrate the utility of a signaling game. There are two questions to explore. First, did the Kennedy Administration believe the Soviet Union was aggressive or defensive? This issue is significant because it suggests whether or not the administration believed a deterrent or tension-reducing response was appropriate. Related to this first question is an important second one: did the administration adhere—either explicitly or implicitly—to the spiral theory or the deterrence theory of conflict? Together, answers to these two questions should provide some idea of the parameters of the game in which American decision makers found themselves. These parameters include the “type” of the other player—whether the Soviet Union was a hawk or dove—and the strategies available to the United States.

That the stakes of this crisis were high is beyond question. Robert Kennedy notes that once the Soviet missiles were discovered in Cuba, American intelligence estimates predicted that eighty million Americans would be killed within a few minutes of their firing (Kennedy 1969: 35–36). Military action to remove the missiles also would have been costly. The President received one estimate that American casualties during an invasion could be greater than 25,000 (Kennedy 1969: 55). Administration officials also considered the costs associated with bombing Cuba: not only would thousands of Cuban civilians die, but the United States might suffer tremendous reputational costs. Sensing the moral difficulty of
attacking a small, poor country, Robert Kennedy passed a note to his brother in which he wrote “I now know how Tojo felt when he was planning Pearl Harbor” (Kennedy 1969: 31). Finally, it goes without saying that the loss of life associated with an all-out nuclear war are inestimable. Rarely if ever have the stakes of a crisis been so high.

Throughout the crisis President Kennedy expressed concern that the crisis risked spiraling out of control. The President’s thoughts clearly reflect an implicit acceptance of the spiral model of conflict:

“The greatest danger and risk in all of this,” he said, “is a miscalculation—a mistake in judgment.” A short time before, he had read Barbara Tuchman’s book The Guns of August, and he talked about the miscalculations of the Germans, the Russians, the Austrians, the French, and the British. They somehow seemed to tumble into war, he said, through stupidity, individual idiosyncracies, misunderstandings, and personal complexes of inferiority and grandeur. . . . Neither side wanted war over Cuba, we agreed, but it was possible that either side could take a step that—for reasons of “security” or “pride” or “face”—would require a response by the other side, which, in turn, for the same reasons of security, pride, or face, would bring about a counter response and eventually and escalation into armed conflict (Kennedy 1969: 62, emphasis added).

After an American reconnaissance aircraft was shot down over Cuba on October 27, 1962, the President again expressed concern that events were spiraling out of control:

At first, there was almost unanimous agreement that we had to attack early the next morning with bombers and fighters and destroy the SAM sites. But again the President pulled everyone back: “It isn’t the first step that concerns me,” he said, “but both sides escalating to the fourth and fifth step—and we don’t go to the sixth because there is no one around to do so. We must remind ourselves we are embarking on a very hazardous course.” (Kennedy 1969: 98).

Nevertheless, the President remained mindful of the consequences of failing to stand up to Soviet actions. Discussing the quarantine with his brother, the President said: “It looks really mean, doesn’t it? But then, really there was no other choice. If they get this mean on this one in our part of the world, what will they do next?” (Kennedy 1969: 67).

Not all in the administration shared President Kennedy’s concern about spirals of hostility nor his ambivalence over the possible course of action. From the outset, the members of the Joint Chiefs of Staff unanimously supported immediate military action (Kennedy 1969: 36). Robert Kennedy records that U.S. military leaders tended to view the Soviets as implacable hawks:

They seemed always to assume that if the Russians and Cubans would not respond or, if they did, that a war was in our national interest. One of the Joint Chiefs of Staff once said to me he believed in a preventive attack against the Soviet Union. On that fateful Sunday morning when the Russians answered they were withdrawing their missiles, it was suggested by one high military adviser that we attack Monday in any case. Another felt that we had in some way been betrayed. (Kennedy 1969: 119).
Military leaders in short advocated a deterrent strategy and tended to view the Soviet Union as hawkish, in contrast to the President’s concern about spirals and belief that Khrushchev had miscalculated.

The uncertainty and ambivalence among members of the Kennedy Administration is understandable given the context in which the missile crisis occurred. The Kennedy Presidency had already experienced one difficult crisis in Berlin in the summer of 1961 that suggested that the Soviet Union had aggressive intentions. In addition to threats to “bury” the West, Khrushchev had embellished the Soviet threat by instructing the Soviet press to parrot the western press’s exaggerated views of Soviet military capabilities (LaFeber 1985: 196). Despite these apparent threats, however, the Soviet Union nevertheless went to some lengths to send peaceful signals as well. In 1957, the Soviet government had announced that “coexistence is not only the absence of war between the two systems, but also peaceful economic competition between them, and concrete cooperation in economic, political, and cultural areas” (LaFeber 1985: 196). Even as technicians prepared the Soviet missile sites in Cuba, Soviet Foreign Minister Andrei Gromyko met with President Kennedy and assured him that “the Soviet Union would never become involved in the furnishing of offensive weapons to Cuba” (Kennedy 1969: 40). In short, the Soviet Union had sent mixed and contradictory signals that lead to understandable confusion and disagreements among Kennedy’s advisors during the missile crisis.

This brief review demonstrates two important elements of the United States’ response to the introduction of Soviet missiles into Cuba. First, members of the Kennedy administration—including the President himself—were uncertain whether the United States and Soviet Union were trapped in a conflictual spiral, or whether the Soviet Union deliberately precipitated the crisis. That is to say, the central theoretical debate between spiral and deterrent theorists at least implicitly informed the debate among the President and his advisors. Second, their debates focused on four central characteristics of the “game” in which they found themselves. These characteristics included the Soviet Union’s intentions (or “type”), the meaning of their actions and messages (or “signals”), the best response of the United States to these actions (or “strategies”), and the costs associated with each possible course of action (or “payoffs”). Together, these elements suggest that game theory may be a useful way of modeling the decision that President Kennedy faced. In doing so, the model can intermediate between the explanations and prescriptions of deterrence theory and the spiral model.

3. The Denouement as a Signaling Game

Toward this end, this paper uses a signaling game to model the end game of the crisis, starting with the receipt of Khrushchev’s first letter of October 27, 1962 that proposed a solution. This model assumes that Khrushchev’s letter is a signal of the Soviet Union’s intentions, or type. The Kennedy Administration then faced a decision; whether to accept this proposed solution (represented as “capitulate” in the model) or to reject it (represented as “fight”). This decision occurred, furthermore, in the context of a series of crises and signals between the Soviet Union and the United States. Starting with the Berlin blockade in 1948, through American U-2 overflights in 1960 and the Berlin Wall crisis of 1961, the signals and strategies during the Cuban missile crisis occurred in the context of an ongoing competition between the Cold War superpowers. A signaling game therefore seems best to capture this interaction between the United States and Soviet Union.
In addition to its appeal as a model of the communication processes that seem prevalent in international crises, the signaling game has two important advantages. First, a signaling game can endogenize the question which spiral and deterrence theorists treat by assumption: whether states are hawks or doves. By using a probability distribution to model the rate at which “nature” generates aggressive and pacific states, the signaling game allows us to test the hypotheses of spiral and deterrence theories utilizing a common set of assumptions, rather than the divergent assumptions about types upon which these theorists rely. Second, a signaling game is also a dynamic game of incomplete information (in the jargon of game theorists); that is, play occurs sequentially, with the first player enjoying an information advantage. This structure is arguably more relevant for international relations than the static models of complete information like the oft-used Prisoner’s Dilemma (see, for instance, Bennett 1995). Often—if not usually—in international relations, a nation-state has information about its intentions that are not public knowledge. Both spiral theory and deterrence theory posit, furthermore, that the interaction of nation-states is iterative; a state’s actions this round will affect the prospects for peace or conflict the next round of play. For these reasons, a signaling game best captures the dynamic interaction of two nation-states with incomplete information. This includes not only the strategies that Khrushchev and Kennedy considered, but the basic structure of many international crises, including the crisis over the Sudetenland in 1938, French and British deliberations over possible American responses to their invasion of the Suez region in 1956, and the signaling between the United States and Iraq during the months before Iraq’s invasion of Kuwait in August 1990. Signaling is so common in international relations that it is surprising that international relations theorists do not use signaling games more frequently.

The following sections presents the extensive form representation of this signaling game and the pure Bayesian equilibrium; appendix A presents the derivation of the equilibrium solution. A few words about the payoff structure are in order, however. The assignment of payoffs in any game is a somewhat arbitrary exercise, a fact that is further complicated by the ambiguities of international relations. Did the Soviet Union and United States share a common assessment of the payoff structure? How can one compare the payoff of an intermediate outcome, such as a possible United States’ capitulation to the Soviet Union’s bluff, to the immeasurable costs of a nuclear war? That there are no apparent or simple answers to these questions suggests that the artifice of a model is an advantage rather than a liability. While the signaling game is simplistic, its very artificiality allows us to forego difficult debates about the relative value of different outcomes. For this reason, the crisis signaling game does not attempt to capture the relative differences between the worst payoff (nuclear war) and the best (opponent backs down). Instead, the game uses rank ordered payoffs both to avoid the insoluble debate about the costs of nuclear war, and to make the game’s findings analogous to a broader range of international conflicts and crises. Nevertheless, the paper tests this assumption to determine which interval values, if any, might change the equilibrium outcome of game. As the proof in appendix B demonstrates, the equilibrium solution for the game remains unchanged for any payoff values provided the assumed rank ordering holds. In other words, the game’s solution changes only if the modeler makes different assumptions about the order of the payoffs. The paper discusses the implication of this finding for both spiral and deterrence theories of conflict.

3.1 Sequence of Play: The sequence of play in this game is as follows. First, nature selects a “type” for the Soviet Union from two possibilities: hawk or dove. To test the two theories of conflict, the paper
defines hawks as nation-states which prefer to threaten in order to deter, while doves are nation-states that prefer to mollify in order to prevent a conflict. It is important to note that neither hawks nor doves prefer war to peace; both are conflict averse, as reflected in the game’s payoffs. They differ, however, in the strategies they utilize to prevent conflict. In order to test the payoffs of spiral versus deterrence theories, we differentiate between hawks and doves in terms of their preferred signals, not their preference for a particular outcome. Since the Soviet Union moves first in this model, the Soviet Union alone knows its type as selected by nature; it is therefore private information that provides the Soviet Union with an advantage.

Next, the Soviet Union sends a signal about its type. Its choice of signal is important in the debate between deterrence and spiral theories. As noted above, states will seek to deter with threats and will seek to avoid spirals with mollifying messages. These assumptions derive directly from deterrence and spiral theories, and seem reasonable. Deterrence theory prescribes threatening signals to prevent aggression “because moderation and conciliation are apt to be taken for weakness,” while spiral theory prescribes that “threats and an adversarial posture are likely to lead to counteractions with the ultimate result that both sides will be worse off than they were before” (Jervis 1976: 59 and 67). For this reason, in the game below the “threat” message represents the prescription of deterrence theory and the “mollify” message represents the prescription of spiral theory.

The United States then receives the Soviet Union’s signal and updates its beliefs about the Soviet Union’s type. That is to say, after the United States receives the Soviet Union’s message, it updates its assessment of the probability that the Soviet Union is hawk instead of a dove. As we shall see, whether or not the United States changes this assessment depends on the nature of the Soviet Union’s message.

In the final step, the United States chooses from two possible actions: it can accept the message (“capitulate”) or it can reject it (“fight”). The terms “capitulate” and “fight” are laden with normative implications that should not cloud the reader’s understanding of the actions. A “capitulation” merely represents the United States’ decision to end the crisis without fighting. Capitulation includes both the possibility of giving into to an aggressive hawk and of cooperating with a pacific dove. Likewise, the term “fight” includes both defending oneself against a hawk or bullying a hapless dove. The important point is that the two actions from which the United States chooses take on their normative meaning from the context of the Soviet type and signal. The actions themselves merely reflect, however, the choice between accepting or rejecting a proposed solution from the Soviet Union.

3.2 Payoff Structure: The payoff structure for the two players are as follows. If nature chooses the “hawk” type for the USSR, the Soviet Union prefers to threaten than to mollify since, by definition of

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1 It is important to note that empirically it is difficult to determine a state’s “type” since states rarely if ever view themselves as “hawks.” For instance, the Soviet Union maintained throughout the crisis that its missiles were strictly “defensive” in nature. Though the Soviet Union and the United States apparently had a semantic disagreement over the meaning of “defensive” versus “offensive” weapons, this disagreement over the nature of the weapon suggests that the Soviet Union may not have viewed itself as a “hawk” (Allison 1971: 41-42). The empirical question of whether or not the Soviet Union considered itself to be an aggressor is not relevant to the subsequent game theoretic analysis, however, since the paper tests a variety of strategies for both hawks and doves.
our types, hawks prefer a deterrent strategy to a tension-reduction strategy. The Soviet Union’s preferred outcome is that the United States capitulate to its threats; this is designated by a three in figure 1. Its second-best payoff is when the United States capitulates even though the Soviet Union sends a mollifying signal. This is the second-best payoff because the hawk prefers peace to war but loses prestige and risks a subsequent conflict by inviting aggression; it is designated as a two in figure 1. Finally, when the United States chooses to fight a hawkish Soviet Union, both players receive zero; this is the equivalent of nuclear war. This outcome is the worst overall payoff for both players. One might argue that in fact the United States might be better off fighting a hawk than a dove because of the reputational costs of beating up on a dove. This argument is not easy to dismiss. To capture the costs of a nuclear holocaust, however, this signaling game denotes a common payoff that is clearly inferior for both players. For simplicity’s sake, the paper assumes that hawks are more likely to be nuclear warriors than doves; when the United States fights a hawk, then, it leads to the worst possible outcome for both players.

If nature chooses the “dove” type for the Soviet Union, by construction it prefers to avoid spirals of hostility than to threaten. The Soviet Union’s preferred outcome is for the United States to capitulate to its mollifying messages, the outcome which the spiral theory suggests is optimal. Its second-best outcome is to send a threatening message to which the United States capitulates. This is second best
because a dove will pay reputational costs by threatening but will avoid fighting a war. This outcome produces a payoff of two. The dove’s inferior solutions are to fight, either after sending a threatening message or a mollifying one. A final simplifying assumption is that doves who must fight will wage a conflict that is less costly than one waged by a hawk. The idea is that since doves are not bellicose, a war with a dove has lower material costs than a war with a hawk, although arguably higher reputational costs. This assumption emphasizes the absolute material destruction associated with nuclear war and discounts reputational costs with the argument that, since reputational costs matter not a bit after a nuclear war, we can compare the two types of conflict only on material costs. (It is worth noting that Robert Kennedy captured the irrelevance of reputational costs when he wrote “I thought, as I listened [to the Joint Chiefs of Staff], of the many times that I had hear the military take positions which, if wrong, had the advantage than no one would be around at the end to know” (Kennedy 1969: 48.).) In figure 1, doves who fight receive a payoff of one, while hawks who fight receive a payoff of zero.

The United States prefers to fight doves but to capitulate to hawks. The reader should recall that the action “fight” does not mean going to war, it merely refers to rejecting a proposal to resolve a crisis. The United States’ highest payoffs are to fight doves. Even if a dove sends a mollifying message, the United States receives a higher payoff by fighting than by capitulating. This reflects the neorealist assumption of zero-sum games in international politics. This seems reasonable for modeling crisis situations in which the perceived risks are so great (such as nuclear holocaust) that nation-states are unlikely to perceive opportunities for positive-sum gains (Lipson 1984; Axelrod and Keohane 1985). To fight a dove gives the United States a payoff of three. After this, the United States preferred payoffs depend upon the message it receives. If the United States receives a threatening message, its second-best payoff is to capitulate to a hawk for a payoff of two. This is because, by assumption, the United States would rather capitulate to a hawk than to invite further aggression by capitulating to a dove. If the United States capitulates to a dove, it receives a payoff of one since the reputational costs are high, but it avoids its least preferred outcome of fighting a hawk. If the United States receives a mollifying message, its second-best payoff is to capitulate to a dove. This is preferable to a capitulation to a mollifying hawk that might invite future aggression. Finally, fighting a hawk, even a mollifying one, is the least-preferred outcome.

It is important to note that the payoffs to player two (the United States) are structured to test the two theories of conflict. The United States sometimes prefers to fight than to capitulate, while in other circumstances it prefers to capitulate. If player two in this game always preferred capitulating to fighting (or vice versa), it would be a meaningless test of deterrence and spiral theories. Dominant preferences only become theoretically interesting in this game if the probability that nature selects a hawk is high (in this game it is 0.5) or if the some payoffs are considerably greater than others (in this game the payoffs are rank-ordered). Given the initial probability and rank-ordered payoffs of this game, it is necessary that player two not have dominant preferences.

While this signaling game is analogous to Cho and Kreps’ “quiche” game (1987: 183–187), it is worth noting the difference in payoff structures. In their game, player two has a choice of two actions: to duel or not. Player two receives simply a payoff of one for dueling a wimp or deferring to a surly, but zero if she defers to a wimp or duels a surly, irrespective of player one’s type. In the crisis signaling game, to make an analogy, it is more costly for player two to “duel a surly” than it is to “duel a wimp.”
That is to say, player two in the crisis signaling game faces higher costs of fighting a hawk than fighting a dove. The assumption behind this difference in fighting payoffs is that war with a nuclear hawk is so incomprehensibly devastating that it is incomparable even to the atrocities and moral repugnancy of bullying a dove.

4. Solution to the Game

Appendix A provides the mathematical derivation of the expected payoffs for both the United States and the Soviet Union. With these expectations, we can begin to determine possible equilibrium solutions. To do this, we will test possible signaling strategies the Soviet Union might pursue and use backward induction to determine payoffs for both players. To narrow the range of possible strategies, deterrence and spiral theories provide some guidance. As noted above, deterrence theorists argue that threats produce higher payoffs than mollifying signals, while spiral theorists argue that mollifying signals will provide the higher payoff. In this sense, one might argue that deterrence theorists call for a “pooling” strategy in which the Soviet Union sends threats irrespective of its type. It is important to note that since a player’s type is private information, the fact that a player is a dove is not sufficient to make a threat non-credible. That is, doves cannot make credible threats precisely because—in game-theory parlance—this is a game of incomplete and imperfect information. Likewise, spiral theorists argue that the Soviet Union should pool on a mollifying signal. This is consistent with the analysis of spiral theories of war: to avoid conflict under the security dilemma, nation-states must signal their peaceful intentions to avoid escalations. As with deterrence theories, spiral theories make no distinction as to the sender’s type: all nations should mollify.

Two theoretically important strategies to test therefore are to pool on threats and to pool on mollification. We should test these strategies, furthermore, against a “separating” strategy in which a hawk always sends a threat, and a dove always sends a mollifying signal. We therefore have three strategies to test for possible equilibria.

To these three strategies we add a fourth to see if it produces an equilibrium. This is a mixed strategy in which doves sometimes disguise their type by mixing their signals. It is reasonable to suspect, for instance, that doves may disguise their type with a mixed strategy. Doves may do this in an attempt to win higher payoffs by “coat-tailing” on the reputational benefits that hawks enjoy. A dove that bluff often may get an opponent to back down. One might speculate, for instance, that during the Cuban Missile Crisis the Soviet Union sent threatening signals in an attempt to win concessions from the Kennedy Administration even though Khrushchev had no intentions of going to war. Perhaps this explains the mixed signals about which Robert Kennedy wrote. In short, one might hypothize that it makes sense for doves to mix their signals. For these reasons, we need to assess whether a strategy where hawks always threaten but doves mix their signals might have a higher payoff than the separating strategy.
The Equilibrium Solution

Table 1 lists the expected payoffs for the four strategies. Given the assumption that nature selects hawk and doves with equal probability \((p = 0.5)\), the separating strategy dominates both of the pooling strategies suggested by spiral and deterrence theory. The payoff of the mixed strategy \(E \Pi (\text{mix})\) depends upon the frequency \(\phi(D)\) with which a dove might send a threatening signal in order to benefit from the reputational benefits of hawks. Since a dove desires to maximize this payoff function, we can take the first-order condition and plot the resulting function to determine the value of \(\phi(D)\) that produces the highest expected payoff. Figure 2 plots the first-order condition. Since by definition of a probability the value of \(\phi(D)\) is between zero and one, figure 2 plots the first-order condition only over this interval. A quick glance at the figure shows that at no point across this interval does the maximized expected payoff exceed zero. (Alternatively, equation 2.4.3 in appendix A demonstrates that the value of the first-order condition is always negative, since the first term is \(-1\).) For this reason, we can conclude that this mixed strategy does not produce higher expected payoff than the separating strategy. In contradiction of the expectations of both spiral and deterrence theorists, the separating strategy is the equilibrium strategy.

The findings of this model are interesting for a number of reasons. Foremost is the observation that the separating strategy dominates the pooling strategies. In this model, nation-states are better off sending messages with meaningful content about their type than they are pooling on threats or mollifying messages. This suggests that both deterrence theory and spiral theories of war produce prescriptions that are overly simplistic. Neither the strategy of always sending threats, suggested by deterrence theory, nor the strategy of always mollifying, as suggested by spiral theory, produces superior expected payoffs for the signaling nation-state. A second interesting observation is that dove-like nation-states who pursue mixed strategies will not be better off than following a pure separating strategy. This is interesting because, contrary to our initial intuition, doves will not receive higher payoffs by disguising their type with some probability. In short, the model shows that in crises like the one modeled here, nation-states are better off giving clear signals about their intentions than by either pooling or mixing.

<table>
<thead>
<tr>
<th>Strategy</th>
<th>(\phi(H))</th>
<th>(\phi(D))</th>
<th>(E \Pi \phi(H))</th>
<th>(E \Pi \phi(D))</th>
<th>(E \Pi \text{(strategy)})</th>
</tr>
</thead>
<tbody>
<tr>
<td>Separating</td>
<td>1</td>
<td>0</td>
<td>3</td>
<td>1</td>
<td>(2p+1 = 2)</td>
</tr>
<tr>
<td>Pool on threat</td>
<td>1</td>
<td>1</td>
<td>(3p = 1.5)</td>
<td>(p+1 = 1.5)</td>
<td>(2p^2+1 = 1.5)</td>
</tr>
<tr>
<td>Pool on mollify</td>
<td>0</td>
<td>0</td>
<td>(2p = 1)</td>
<td>(2p + 1 = 1.5)</td>
<td>(p+1 = 1.5)</td>
</tr>
</tbody>
</table>
| Mixed          | 1          | \(0<\phi(D)<1\) | 3                  | \(0.5\phi(D)\)     | \[
\frac{3+2\phi(D)-\phi(D)^2}{[1+\phi(D)]^2}\]

Table 1: Expected Soviet payoffs from possible strategies, crisis signaling game.
Figure 2: Plot of the first-order condition of the Soviet Union’s expected payoff function over the interval 0 to 1. Note that at no point does the value of the maximized payoff function exceed zero.

5. Alternative Assumptions About Payoffs

The assumption of rank-ordered payoffs predicates the preceding analysis. Would specifying intervals between payoffs alter the equilibrium solution in any way? For instance, one might argue that since nuclear war is so much worse than capitulating to a bully, the likely equilibrium solution to the game is the pooling strategy suggested by spiral theorists. By similar logic deterrence theorists may argue that other intervals between payoffs make their proposed pooling strategy the equilibrium outcome. In other words, critics might argue the assumption of ordinal payoffs grossly oversimplifies the calculations that statesmen must make in times of crises. If so, deterrence or spiral theorists may provide an accurate model of conflict provided we can determine empirically the payoffs of the signaling game.

The proof in appendix 2 demonstrates that the dominance of the separating strategy holds for any intervals provided that the order of payoffs is preserved. It is the order of payoffs that determines the
equilibrium solution in signaling games, not the specific value or interval between any given payoffs. This finding demonstrates that the prescriptions of deterrence and spiral theorists, as represented by the pooling strategies in this signaling game, derive from their assumptions about the nature of states—or in terms of this game, about the distribution of state types within the international system. Deterrence theorists see a world populated by hawks, or one where the $p$ value of the game is 1. Likewise spiral theorists see a world of doves ($p = 0$). As a consequence, their theoretical findings proceed axiomatically from their assumptions about state types. As the signaling game demonstrates, such logic is tautological. Neither theory adequately captures the dynamics of crises and conflict processes among states. What theorists of international conflict require is a theoretical specification which endogenizes the question of state types.

6. Conclusions

Perhaps these findings are unsurprising: in crises or conflicts analogous to this signaling game, nation-states fare better when they pursue a separating strategy that clearly signals their intentions. Nation-states are better off when they are unambiguous about their interests. This model points out, however, a theoretical insufficiency of deterrence and spiral theories. In the model, the pooling strategies that these theories prescribe do not produce expected payoffs that are better than the payoffs of the pure separating strategy under any probability distribution of the type of states in the game: that is, with rank-ordered payoffs there is no possibility that a state would either always threaten or always mollify. Even a mixed strategy, in which a dove tries to bluff with an occasional threat, does not fare as well as the pure separating strategy. This suggests that the effectiveness of deterrent and ameliorating signals depends upon the sender’s type, not the receiver’s type as deterrence and spiral theorists suggest. For this reason, spiral and deterrence theorists must endogenize within their perspectives a theoretical specification of the different types of nation-states. As they stand now, both theories merely make assumptions about types which by construction make the theory’s prescriptions self-fulfilling. That is to say, in a world of hawks, a deterrent strategy in fact will in fact produce higher payoffs, but the mere assumption that the world is populated by hawks tells us nothing about the validity of deterrence theory. Both theories therefore need to move beyond their assumptions to specify the relationship between state types, the prospective payoffs that states face, and spirals or deterrence. The role of payoffs is of particular theoretical importance since, as this game has shown, in a situation of rank-ordered payoffs, pure deterrent or ameliorating strategies never yield better results than a separating strategy.

A second implication of the superiority of separating strategies is the importance of clear signals. As the opening epigraph of this paper suggests, during the Cuban missile crisis the Soviet Union’s signals were anything but clear, a general observation that scholars of international crises often make. Political scientists have identified several practices in international relations that nation-states use to clarify their signals in conflicts or crisis situations. One is the common practice in which states make concessions in related but separate issue areas to signal their peaceful intent. James D. Morrow (1992) has found, however, that linkage often fails to clarify messages in signaling games. Another device is arms control verification. For instance, in 1955 President Eisenhower offered the “open skies” proposal “to lessen the fears and dangers of surprise attack by establishing an effective warning system” (Stanford Arms Control Group 1984: 288; see also Schelling 1980: 230). For similar purposes, on-site inspections are now the backbone of the verification regimes for the START and INF treaties. Such arms control
measures operate much like the regime of diplomatic immunity; states choose to relax their sovereign rights in order to improve the clarity of signals. Donald Wittman (1989) shows how verification regimes can improve signaling by making “cheating” unambiguous and costly. In these ways, one might think of arms control and issue linkage as regimes and techniques that facilitate an optimal separating strategy.

A related way of thinking about arms control and linkage is that they are two of many ways that states change the payoffs they face in a game. Issue linkage simply changes the rewards of some actions (Lebow 1996: 74–76). Gerald L. Sorokin (1996) argues, however, that the use of rewards may alter states’ strategies for better or for worse. He notes that in crises in particular, states that receive demands “might refuse to acquiesce, even when its complete information-expected utility for acquiescence is greater than its expected utility for refusing, hoping that its adversary will offer a reward” (Sorokin 1996: 669). In his discussion of U.S.-Soviet negotiations during the Cuban missile crisis, Sorokin finds that the U.S. altered the Soviet Union’s expected payoff by tacitly agreeing to withdraw Jupiter missiles from Turkey (Sorokin 1996: 675). Similarly, Langlois and Langlois (1996) argue that nation-states use “counterveiling” strategies which can produce subgame-perfect equilibria by altering the other player’s payoff (Langlois and Langlois, 1996). In these ways, nation-states may agree to regimes and institutions that make separating strategies perfect Bayesian equilibria in signaling games.

This crisis signaling game also begs some important questions about the transparency of signals in the international system. Just as Clausewitz warned about the fog of war, the “fog” of crises also may obscure the processes of communication between states. Robert Jervis for one sees two psychological causes of misperception that may be pertinent to signaling during crises. First, Jervis argues that states tend to overestimate the clarity of the messages they send; the Kennedy Administration’s confusion over Khrushchev’s messages may attest to this. Second, Jervis notes that statesmen tend to view other states as more hostile—as well as more centralized, disciplined, and coordinated—than they really are (Jervis 1996: 526–529). This tendency to see others as hostile and monolithic suggests that, in the terms of the crisis signaling game, the prior belief that a state is a hawk is likely to be greater than 0.5. Together, these barriers to miscommunication suggest that the crisis signaling game both oversimplifies the ease of signaling during crises and underestimates the effect of the security dilemma on a state’s estimate of another’s hostile intent.

This signaling game also has an interpretation that is consistent with the arguments of democratic peace theorists, particularly those who emphasize the role of democratic institutions in keeping the peace among democracies (Morgan and Campbell 1991; Lake 1992; Mintz and Geva 1992; Morgan and Schwedbach 1992; Schweller 1992; Russel and Maoz 1993). Since a state’s type is private information, one can argue that a state’s belief about another’s type represents simply an estimation about an opponent’s domestic factional politics: in the case of the Cuban Missile Crisis, for example, the Kennedy Administration was concerned about whether or not the “hawks” in the Politburo would prevail in their struggle with the “doves” (Allison 1971: 112–113). When one considers a state’s type in the context of its domestic politics, the institutions of democracy allow clearer signaling about a state’s “type” in times of crises. A state’s leader will be more certain about the ascendancy of hawks and doves due to the relative transparency of democratic institutions. This greater certainty in times of crisis may help democracies resolve conflicts through clearer signals, or—in the terms of this paper—a clear separating strategy.
Perhaps most importantly, the crisis signaling game demonstrates the importance of using an appropriate game to test theoretical questions. The oft-cited Prisoner’s Dilemma, a static game of perfect information, yields no real insights into deterrence or spiral theories of conflict; in fact, adherents of both theories have different perspectives on which static game is the appropriate analogy (Jervis 1976: 67). Because it is a dynamic game of incomplete information, the signaling game offers not only a more appropriate metaphor for crisis bargaining but a means of testing whether or not deterrent strategies perform better than the tension-reduction strategies advocated by spiral theorists.

The conclusion of the Cuban missile crisis is well known. The Kennedy Administration accepted Khrushchev’s first proposal, and within a year the United States had dismantled its missiles in Turkey. One could argue, of course, that Khrushchev’s chronic ambiguity in his signals, at once threatening and mollifying, were analogous to the inferior pooling and mixing strategies in the crisis signaling game. The purpose of the game in this paper is not, however, to explain the outcome of the missile crisis. Rather the game demonstrates the important need for deterrent and spiral theories alike to specify theoretically state types in their models.
Appendix A: Solution of the Crisis Signaling Game

1. Structure of the Game

To solve the crisis signaling game, we must specify four characteristics of the game. First, we need to specify the “types” of player that nature may select for the Soviet Union. Since we seek to test deterrence and spiral theories of conflicts, we will designate the two possible types of Soviet Union as “hawk” and “dove” to model the disagreement between deterrence and spiral theories about the role of threats in interstate conflict. Second, we need to specify the United States’ beliefs about the Soviet Union’s type. There are two elements to these beliefs: a probabilistic assessment of the type that nature assigns to the Soviet Union (the prior belief), and a probabilistic assessment of the Soviet Union’s type given a specific signal that the Soviet Union sends (the posterior belief). Third, we need to specify the range of possible actions that the Soviet Union and the United States each may take (or action space). To simplify, we assume that both actors have only two possible actions. The Soviet Union’s actions are signals; it may send either a threatening signal or a mollifying one. The United States’ actions are a response to whatever signal the Soviet Union sends; it may capitulate or it may fight. In either case, the United States’ choice of action ends the game and both nation-states receive the payoffs depicted in figure 1. Finally, we must specify the strategies of the Soviet Union and the United States. With a specification of types, beliefs, action spaces, and strategies, we can determine the perfect Bayesian equilibrium solution to this game.

1.1 Types: Nature determines the Soviet Union’s type from \( t \in \{H, D\} \) where “H” is a hawk and “D” is a dove.

1.2 Action spaces: In this game, each player has two possible actions. For the Soviet Union, the action space consists of two signals: a threatening message (\( T \)) or a mollifying one (\( M \)). Notationally, we can represent the Soviet Union’s action space as \( a_{USSR} \in \{T, M\} \). The United States then moves by choosing from two actions, to capitulate to the message (\( c \)) or to fight (\( f \)). The notation for the United States’ action space is: \( a_{US} \in \{c, f\} \).

1.3 Strategies: We can now denote the strategies of the Soviet Union and the United States as functions. We will assume that the Soviet Union chooses either to threaten or to mollify with a full range of play such that the probability \( p \) of either action is \( p \in \{0,1\} \). The Soviet Union’s strategy is the function \( \phi(t) \), which denotes the probability that it will send a threat \( T \) given it is type \( t \):

\[
\phi: \{H, D\} \to [0,1] \\
\phi(t) = \Pr(T|t) \\
\text{and} \\
1 - \phi(t) = \Pr(M|t)
\]

(1.3.1)

Likewise, we can represent the United States’ strategy as a function, where \( \gamma(a) \) represents the probability that the United States will fight given action \( a \):
\[
\gamma : \{T, M\} \to [0,1] \\
\gamma(a) = \Pr(f|a) \\
\text{and} \\
1 - \gamma(a) = \Pr(c|a)
\]  

(1.3.2)

1.4 Beliefs: To calculate the equilibrium solution to this game, we must first specify the prior and posterior beliefs of the second player, the United States. The United States’ prior belief is simply the odds with which nature selects a hawk instead of a dove. In this game, by assumption the prior is equal to 0.5, or \( \Pr(t = H) = 0.5 \). The United States’ calculates its posterior beliefs as a function of the message it receives from the Soviet Union. Because posterior beliefs are a function of the probability of a given message \( a \), we denote the posterior belief that the Soviet Union is a hawk as \( \Pr(H|a) \).

2. Solution

Given these strategy functions, we can use backward induction to determine what message the Soviet Union should send to maximize its payoff in this game. To start, we determine the United States’ expected payoff \( E\Pi_{US} \) given the strategy functions of the United States (equation 1.3.2) and the maximized strategy of Soviet Union \( \phi^*(t) \) (equation 1.3.1):

\[
E\Pi_{US}\left[ \gamma(a)|\phi^*(t) \right] = \gamma(a)\left\{ \Pr(H|a) \cdot 0 + \left(1 - \Pr(H|a)\right) \cdot 3 \right\} + \\
\left\{ \left[1 - \gamma(a)\right] \cdot \left[ \Pr(H|a) \cdot 2 + \left(1 - \Pr(H|a)\right) \cdot 1 \right] \right\}
\]  

(2.0.1)

Simplifying this equation, we get:

\[
E\Pi_{US}\left[ \gamma(a)|\phi^*(t) \right] = 2\gamma(a) \cdot \left[1 - 2 \Pr(H|a)\right] + \Pr(H|a) + 1
\]

The United States will seek to maximize these payoffs. Therefore, the first-order condition of this expected payoff will provide the maximized payoff. The partial derivative is:

\[
\frac{\partial E\Pi_{US}}{\partial \gamma(a)} = 2 \cdot \left[1 - 2 \Pr(H|a)\right] \\
= 2 - 4 \Pr(H|a)
\]  

(2.0.2)

By taking this first-order condition and making it greater than zero, we can determine the probability that the Soviet Union is a hawk under which the United States would choose to fight:
\[
2 - 4 \Pr(T|a) > 0 \\
(2.0.3) \quad 4 \Pr(T|a) < 2 \\
\Pr(T|a) < 0.5
\]

The United States therefore will fight the Soviet Union if the chances that the Soviet Union is a hawk are less than 0.5. This makes intuitive sense; the United States should reject a dove’s ultimatum but accede to a hawk’s. In the crisis signaling game, the United States will maximize its payoffs by rejecting the Soviet message if it believes the Soviet Union is a dove, or by acceding to it if it believes the Soviet Union is a hawk. Notationally:

\[
\Pr(H|a) \geq 0.5 \Rightarrow \gamma^*(a) = 0 \\
\Pr(H|a) < 0.5 \Rightarrow \gamma^*(a) = 1
\]

It is worth noting, furthermore, that in this subgame the posterior belief is equal to the prior belief, which by assumption is 0.5.

Now that we know the United States’ maximization strategy \( \gamma^*(a) \), we can deduce what signals the Soviet Union will send to maximize its payoff given \( \gamma^*(a) \). We can represent this as:

\[
E \Pi_{USSR} \left[ \phi(H) \bigg| \gamma^*(a) \right] = \phi(H) \left\{ \gamma^*(T) \cdot 0 + \left[ 1 - \gamma^*(T) \right] \cdot 3 \right\} + \\
\left[ 1 - \phi(H) \right] \left\{ \gamma^*(M) \cdot 0 + \left[ 1 - \gamma^*(M) \right] \cdot 2 \right\}
\]

and:

\[
E \Pi_{USSR} \left[ \phi(D) \bigg| \gamma^*(a) \right] = \phi(D) \left\{ \gamma^*(T) \cdot 1 + \left[ 1 - \gamma^*(T) \right] \cdot 2 \right\} + \\
\left[ 1 - \phi(D) \right] \left\{ \gamma^*(M) \cdot 1 + \left[ 1 - \gamma^*(M) \right] \cdot 3 \right\}
\]

With these expected payoffs, we will test four possible strategies and use backward induction to determine the payoffs for each player. By testing the most theoretically interesting strategies, we can determine which strategy produces the equilibrium outcome. The following sections test the four most interesting strategies: a separating strategy; a pool-on-threat strategy to model deterrence theory; a pool on mollify strategy to model spiral theory; and a mixed strategy in which doves try to disguise their type in order to take advantage of the reputational benefits of hawks.
2.1 The Separating Strategy: In the separating strategy, a hawk always sends a threat, while a dove always sends a mollifying signal. In this way, the signal “separates” the type of the first player and provides the second player with a clear choice. In the series of Cold War crises, for instance, the Soviet Union might have pursued a separating strategy so that it signaled without ambiguity its intentions (or type). Since hawks always send threats and doves never do, we can use equation 2.3.1 to represent this strategy:

\[ \phi(H) = 1 \]
\[ \phi(D) = 0 \]

We can now calculate the compound probability that the Soviet Union is a hawk given a threatening signal, or \( \Pr(H|T) \). By definition of a separating strategy, we can intuit that \( \Pr(H|T) \) is equal to one, but we can prove this using Bayes’ Theorem:

\[
\Pr(H|T) = \frac{\Pr(T|H) \cdot \Pr(H)}{\Pr(T|H) \cdot \Pr(H) + \Pr(T|D) \cdot [1 - \Pr(T)]}
\]

Since the probability of a hawk, or \( \Pr(H) \), is the prior belief \( p \), we can solve this equation by substituting our values of \( \phi(H) \), \( \phi(D) \) and \( \Pr(H) \):

\[
\Pr(H|T) = \frac{1 \cdot p}{1 \cdot p + 0 \cdot (1 - p)} = 1
\]

which is consistent with our intuitive expectation.

We can now calculate the Soviet Union’s expected payoffs from the separating strategy by using these values of \( \phi(H) \), \( \phi(D) \) and \( \Pr(H|T) \) in equation 2.0.4:

\[
E \Pi_{\text{USSR}}[\phi(H)] = \phi(H)[0 \cdot 1 + 1 \cdot 3] + [1 - \phi(H)][0 \cdot 0 + 1 \cdot 2]
\]
\[
= 3\phi(H) + 2 - 2\phi(H)
\]
\[
= \phi(H) + 2
\]
\[
= 3
\]

and then into equation 2.0.5:
\[ E \Pi_{\text{USSR}}[\phi(D)] = \phi(D)[1 \cdot 1 + 0 \cdot 2] + [1 - \phi(D)] \cdot [1 \cdot 1 + 0 \cdot 3] \]
\[ = \phi(D) + 1 - \phi(D) \]
\[ = 1 \]

The Soviet Union’s expected payoffs from this strategy is simply the sum of each of these expected payoffs multiplied by the probability of each type:

\[ E \Pi_{\text{USSR}}(\text{separating}) = 3 \cdot p + 1 \cdot (1 - p) \]
\[ = 3p + 1 - p \]
\[ = 2p + 1 \]
\[ = 2 \cdot (0.5) + 1 \]
\[ = 2 \]

The reader will recall that, by definition, \( p \) is the prior belief of the probability with which nature selects a hawk. In this game, nature selects hawks with \( p = 0.5 \). By substituting this value of \( p \) into the equation 2.1.1, we determine that the Soviet Union’s expected payoff for a separating strategy is 2.

To determine whether or not the separating strategy produces a perfect Bayesian equilibrium, we must check other strategies off the equilibrium path to determine whether or not they produce higher expected payoffs. If the pooling strategies or the mixed strategy for doves produce higher expected payoffs, then the separating strategy is not a perfect Bayesian equilibrium.

2.2 Pool on Threaten: Deterrence theory suggests that credible threats should provide a higher payoff than either a separating strategy or an appeasement strategy of pooling on mollifying signals. That is to say, the prescription of deterrence theory takes no account of the sender’s type; both hawks and doves should always send threatening messages. Does a pooling strategy in which the Soviet Union always sends threats irrespective of its type produce higher payoffs in this signaling game? This strategy implies that the Soviet Union always threatens irrespective of its type:

\[ \phi(H) = 1 \]
\[ \phi(D) = 1 \]

Calculating the United States’ posterior beliefs using Bayes’ equation produces the intuitive finding that the posterior belief is merely the prior belief \( p \). This makes sense with pooling strategies, since the message the Soviet Union sends contains no information regarding its types:
\[
\Pr(H|T) = \frac{1 \cdot p}{1 \cdot p + 1 \cdot (1 - p)} = p
\]

We can now calculate the Soviet Union’s expected payoffs. Since the United States does not have a dominant strategy in the face of this uncertainty, it will fight \( \gamma^*(f) \) with probability \( 1 - p \) and will capitulate \( \gamma^*(c) \) with probability \( p \). The Soviet Union’s expected payoffs therefore are:

\[
E \Pi_{\text{USSR}}[\phi(H)] = \phi(H) \left[ (1 - p) \cdot 0 + p \cdot 3 \right] + \left[ 1 - \phi(H) \right] \left[ p \cdot 0 + (1 - p) \cdot 2 \right]
\]

\[
= 3p \phi(H) + \left[ 1 - \phi(H) \right] \cdot (2 - 2p)
\]

\[
= 3p
\]

and:

\[
E \Pi_{\text{USSR}}[\phi(D)] = \phi(D) \left[ (1 - p) \cdot 1 + p \cdot 2 \right] + \left[ 1 - \phi(D) \right] \left[ p \cdot 1 + (1 - p) \cdot 3 \right]
\]

\[
= \phi(D) \cdot [2p + 1 - p]
\]

\[
= p + 1
\]

The overall payoff for the strategy therefore are:

\[
E \Pi_{\text{USSR}}(\text{pool on } T) = p \cdot 3p + (1 - p) \cdot (p + 1)
\]

\[
= 3p^2 + p + 1 - p^2 - p
\]

\[
= 2p^2 + 1
\]

\[
= 2 \cdot (0.5)^2 + 1
\]

\[
= 1.5
\]

(2.2.1)

We can compare these payoffs in equation (2.2.1) to the expected payoff of the separating strategy (2.1.1) to determine which produces a preferred outcome. If pooling on threats is to dominate the separating strategy, then its expected payoffs must exceed the expected payoffs of the separating strategy:
2p^2 + 1 > 2p + 1
2p^2 - 2p > 0
2p \cdot (p - 1) > 0
p - 1 > 0
p > 1

In other words, pooling on threats dominates the separating strategy only when \( p > 1 \). Since by definition \( p \) is a probability, it must be between 0 and 1. The value of \( p \) therefore can never exceed 1, proving that the separating strategy dominates the strategy of pooling on threats. This pooling strategy therefore cannot produce a perfect Bayesian equilibrium. This is consistent, of course, with our calculated values of \( E\Pi(\text{separating}) = 2 \) and \( E\Pi(\text{pool on threat}) = 1.5 \).

2.3 Pool on Mollify: An alternative strategy for the Soviet Union might be to send placating signals irrespective of its true type. This is consistent with the prescription of spiral theories of war. A pooling strategy of mollifying signals implies that:

\[
\phi(H) = 0 \\
\phi(D) = 0
\]

As with the strategy to pool on threats, we know that the United States’ posterior beliefs \( q \) are equal to the prior \( p \) since the Soviet Union’s choice of signal conveys no information about its type. With this knowledge of the United States’s posterior beliefs we can calculate the Soviet Union’s expected payoff:

\[
E\Pi_\text{USSR} [\phi(H)] = \phi(H) \left[ q \cdot 0 + (1 - q) \cdot 3 \right] + \left[ 1 - \phi(H) \right] \cdot [(1 - q) \cdot 0 + q \cdot 2] \\
= \phi(H) \left[ 3 - 3q \right] + \left[ 1 - \phi(H) \right] \cdot (2q) \\
= 0 \cdot (3 - 3q) + 1 \cdot 2q \\
= 2q \\
= 2p
\]

Since, by definition of a pooling strategy, the posterior belief \( q \) is equivalent to the prior belief \( p \), we can substitute \( p \) for \( q \) in the last line above. The Soviet Union’s expected payoff as a dove are:
\[ E \Pi_{USSR}[\phi(D)] = \phi(D) \left[ q \cdot 1 + (1 - q) \cdot 2 \right] + \left[ 1 - \phi(D) \right] \cdot \left[ (1 - q) \cdot 1 + q \cdot 3 \right] \]
\[ = \phi(D) [2 - q] + [1 - \phi(D)] \cdot (2q + 1) \]
\[ = 0 \cdot (2 - q) + 1 \cdot (2q + 1) \]
\[ = 2q + 1 \]
\[ = 2p + 1 \]

Therefore the expected payoff for the strategy of pooling on mollifying signals is:

\[ E \Pi_{USSR}(\text{pool on } M) = p \cdot 2p + (1 - p) \cdot (2p + 1) \]
\[ = 2p^2 + 2p + 1 - 2p^2 - p \]
\[ = p + 1 \]
\[ = 0.5 + 1 \]
\[ = 1.5 \]

By comparing this value to equation 2.1.1, we can demonstrate that the separating strategy dominates the strategy of pooling on mollifying signals.

2.4 *Doves Will Pursue a Mixed Strategy:* One interesting mixed strategy is for doves to disguise their type by occasionally sending threatening signals. Doves may do this in an attempt to win higher payoffs by “coat-tailing” on the reputational benefits that hawks enjoy. That is to say, by occasionally sending threatening signals, doves sometimes may gain a higher payoff than they would if they pursue a separating strategy. For this reasons, we need to assess whether a strategy where hawks always threaten but doves mix their signals might have a higher payoff than the separating strategy.

Under this mixed strategy, hawks always send threats but doves send threats with a probability less than one. We can denote these probabilities that each sends a threatening signal as:

\[ \phi(H) = 1 \]
\[ 0 < \phi(D) < 1 \]

With this knowledge of the probabilities with which hawks and doves send threats, we can calculate the probability that a threatening player is a hawk using Bayes’ Theorem:
\[
\Pr(H|T) = \frac{1 \cdot p}{1 \cdot p + \phi(D)[1 - p]}
\]
\[
= \frac{p}{p + \phi(D) - \phi(D) \cdot p}
\]
\[
= \frac{p}{p \cdot [1 - \phi(D)] + \phi(D)}
\]
\[
= \frac{0.5}{0.5 \cdot [1 - \phi(D)] + \phi(D)}
\]
\[
= \frac{1}{1 + \phi(D)}
\]

(2.4.1)

We substituted the known value \( p = 0.5 \) in the above equation to get the probability \( \Pr(H|T) \) as a function of \( \phi(D) \).

Using this function we can now solve the expected payoffs for the Soviet Union from this mixed strategy. Since hawks always send a threatening signal, \( E\Pi_{USSR}[\phi(H)] \) is the same as in the case of the separating strategy:

\[
E\Pi_{USSR}[\phi(H)] = \phi(H)[0 \cdot 1 + 1 \cdot 3] + [1 - \phi(H)] \cdot [0 \cdot 0 + 1 \cdot 2]
\]
\[
= 3\phi(H) + 2 - 2\phi(H)
\]
\[
= \phi(H) + 2
\]
\[
= 3
\]

Solving for \( E\Pi_{USSR}[\phi(D)] \) is more difficult since \( \phi(D) \) is an unknown variable:

\[
E\Pi_{USSR}[\phi(D)] = \phi(D) \cdot \{p \cdot 1 + (1 - p) \cdot 2\} + [1 - \phi(D)] \cdot \{(1 - p) \cdot 1 + p \cdot 3\}
\]
\[
= \phi(D) \cdot [p + 2 - 2p] + [1 - \phi(D)] \cdot [1 - p + 3p]
\]
\[
= \phi(D)(2 - p) + [1 - \phi(D)](1 + 2p)
\]
\[
= 2\phi(D) - \phi(D)p + 1 + 2p - \phi(D) - 2\phi(D)p
\]
\[
= \phi(D) - 3\phi(D)p + 2p + 1
\]
\[
= \phi(D) \cdot (1 - 3p) + 2p + 1
\]
Substituting the prior belief \( p = 0.5 \) into the equation above provides:

\[
E \Pi_{USSR} [\phi(D)] = \phi(D) \cdot [1 - 3 \cdot (0.5)] + 2 \cdot (0.5) + 1 \\
= 2 - 0.5\phi(D)
\]

We can now calculate the expected payoff of this strategy by multiplying these expected payoffs with their probability:

\[
E\Pi_{USSR} [\text{mix}] = 3 \cdot \left[ \frac{1}{1 + \phi(D)} \right] + [2 - 0.5\phi(D)] \cdot \left[ 1 - \frac{1}{1 + \phi(D)} \right] \\
= \frac{3}{1 + \phi(D)} + 2 - \frac{2}{1 + \phi(D)} - 0.5\phi(D) + \frac{0.5\phi(D)}{1 + \phi(D)} \\
= \frac{3 - 2 + 0.5\phi(D)}{1 + \phi(D)} - 0.5\phi(D) + 2 \\
= \frac{1 + 0.5\phi(D)}{1 + \phi(D)} - 0.5\phi(D) + 2 \\
= \frac{1 + 0.5\phi(D) - 0.5\phi(D) \cdot [1 + \phi(D)] + 2 \cdot [1 + \phi(D)]}{1 + \phi(D)} \\
= \frac{3 + 2\phi(D) - 0.5\phi(D)^2}{1 + \phi(D)}
\]  

(2.4.2)

Since the Soviet Union desires to maximize this payoff function, we can take the first-order condition to determine the value for \( \phi(D) \) that produces the greatest expected payoffs. Using the quotient rule, we get the following first-order condition:

\[
\frac{\partial E\Pi_{USSR}[\text{mix}]}{\partial \phi(D)} = \left[ 2 - \phi(D) \right] \left[ 1 + \phi(D) \right] - 1 \cdot \left[ 3 + 2\phi(D) - 0.5\phi(D)^2 \right] \\
= \frac{2 + 2\phi(D) - \phi(D) - \phi(D)^2 - 3 - 2\phi(D) + 0.5\phi(D)^2}{\left[ 1 + \phi(D) \right]^2} \\
= -1 - \phi(D) - 0.5\phi(D)^2 \\
= \frac{-1 \cdot \left[ 0.5\phi(D)^2 + \phi(D) + 1 \right]}{\left[ 1 + \phi(D) \right]^2}
\]  

(2.4.3)
This first-order condition is plotted in figure 2 on page 13. Since by construction the value of $\phi(D)$ is between zero and one, figure 2 plots the first-order condition only across this interval. A quick glance at the figure shows that at no point across this interval does the maximized expected payoffs exceed zero. (Alternatively, it is apparent that the value of the first-order condition is always negative, since the first term is $-1$.) For this reason, we can conclude that this mixed strategy does not produce a higher expected payoff than the separating strategy.

The separating strategy equilibrium appears to be the perfect Bayesian equilibrium. It satisfies the four conditions of perfect Bayesian equilibria: we have determined the United States’ payoffs on the basis of its beliefs about which node of the information set is has reached; calculated sequentially rational strategies; we have determined the United States’ beliefs at its information set using Bayes’ rule and the Soviet Union’s equilibrium strategy; and have checked other strategies off the equilibrium path using Bayes’ rules and the Soviet Union’s equilibrium strategies (Gibbons 1992: 177–180). While we have not checked the full range of mixed strategies off the equilibrium path to determine whether or not they produce higher expected payoffs, we have tested the most theoretically interesting mixed strategy.
Appendix B: Equilibrium Holds For All Rank Ordered Payoffs

For the purposes of testing spiral and deterrence theories, this paper assumes rank-ordered payoffs for its adaptation of Cho and Kreps’ signaling game. Though the paper assigns only ordinal values to these rank-ordered payoffs, the equilibrium solution holds for all values of the payoffs provided the rank ordering is preserved. In other words, given this order there is no combination of payoffs for which a mixing or pooling strategy will dominate the separating strategy. The value of the payoffs doesn’t matter; only the order of the payoffs does. Hence it is this assumption which drives the crisis signaling game.

To prove this, recall that the payoff functions for the Soviet Union are:

\[
E\Pi_{USSR}\left[\phi(H)|y^*(a)\right] = \phi(H)\left\{y^*(T) \cdot 0 + \left[1 - y^*(T)\right] \cdot 3\right\} + \\
\left[1 - \phi(H)\right]\left\{y^*(M) \cdot 0 + \left[1 - y^*(M)\right] \cdot 2\right\}
\]

(1.0.1)

and:

\[
E\Pi_{USSR}\left[\phi(D)|y^*(a)\right] = \phi(D)\left\{y^*(T) \cdot 1 + \left[1 - y^*(T)\right] \cdot 2\right\} + \\
\left[1 - \phi(D)\right]\left\{y^*(M) \cdot 1 + \left[1 - y^*(M)\right] \cdot 3\right\}
\]

(1.0.2)

By treating the payoffs as variables instead of fixed values, we can determine for which values of the payoffs if any the equilibrium solution will change. Let \(A\) equal the highest payoff (which is 3 in the crisis signaling game), \(B\) will designate the second highest payoff (assigned a 2 in the crisis signaling game), \(C\) equals the second lowest (a 1 in the game), and \(D\) the lowest payoff (0). Recall our restriction that though the payoff values may vary, their order cannot:

\[
\begin{align*}
3 & = A \\
2 & = B \\
1 & = C \\
0 & = D
\end{align*}
\]

Restriction: \(A > B > C > D\)

We can now substitute our variables into the Soviet Union’s expected payoffs (1.0.1 and 1.0.2):
\[ E\Pi_{USSR}[\phi(H)|\gamma^*(a)] = \phi(H)\{\gamma^*(T) \cdot D + [1 - \gamma^*(T)] \cdot A\} + \\
\quad [1 - \phi(H)]\{\gamma^*(M) \cdot D + [1 - \gamma^*(M)] \cdot B\} \]

(1.0.3)

\[ E\Pi_{USSR}[\phi(D)|\gamma^*(a)] = \phi(D)\{\gamma^*(T) \cdot C + [1 - \gamma^*(T)] \cdot B\} + \\
\quad [1 - \phi(D)]\{\gamma^*(M) \cdot C + [1 - \gamma^*(M)] \cdot A\} \]

(1.0.4)

Now that we have created variable payoff functions, we can calculate the values for each of the four strategies tested in the crisis signaling game.

**A. The Separating Strategy**: Recall that with a separating strategy, a hawk will always send threats while a dove never will. Using equation (2.3.1) from appendix A, we can notationally represent this strategy as:

\[ \phi(H) = 1 \]
\[ \phi(D) = 0 \]

We can substitute these values into equations (1.0.3) and (1.0.4), then multiple each payoff function by the probability \( p \) with which nature selects a hawk or dove. By adding these two terms together, we then calculate the expected payoff for the separating strategy:

\[ E\Pi_{USSR}(\text{sep}) = \left(p \times \{\phi(H)[0 \cdot C + 1 \cdot A] + [1 - \phi(H)]\{0 \cdot D + 1 \cdot B\}\}\right) + \\
\quad \left([1 - p]\{\phi(D)[1 \cdot C + 0 \cdot B] + [1 - \phi(D)]\{1 \cdot C + 0 \cdot A\}\}\right) \]

\[ = \left(p \times \{\phi(H) \cdot A + [1 - \phi(H)] \cdot B\}\right) + \\
\quad \left([1 - p]\{\phi(D) \cdot C + [1 - \phi(D)] \cdot C\}\right) \]

Recall that by assumption, the probability \( p \) with which nature selects hawks is 0.5. Using this value for \( p \) and the strategy’s values for \( \phi(H) \) and \( \phi(D) \), we can simplify the above:

\[ E\Pi_{USSR}(\text{separating}) = 0.5\{1 \cdot A + 0 \cdot B\} + (1 - 0.5)\{0 \cdot C + 1 \cdot C\} \]

(1.1.1)

\[ = 0.5 \cdot A + 0.5 \cdot C \]

\[ = 0.5(A + C) \]
This is the generic expected payoff function for the separating strategy when we allow the values of the payoffs to vary within the restriction of the payoff order. We can follow the same procedure to derive the generic expected payoff functions for the two pooling strategies.

(B) Pooling on Threat: The crisis signaling game uses the pool on threat strategy to model deterrence theory. Recall that deterrence theorists view threats as preventing conflict rather than precipitating it. Given that a state will always threaten irrespective of its type, we can represent this strategy as:

\[
\phi(H) = 1 \\
\phi(D) = 1
\]

After calculating the second player’s posterior beliefs, we can calculate player one’s expected payoffs. Because player two does not have a dominant strategy in the face of uncertainty, it will fight with probability \(1 - p\) and will capitulate with probability \(p\). Player one’s expected payoffs for each possibility therefore are:

\[
E\Pi_{\text{USSR}}[\phi(H)] = \phi(H)\left[(1 - p) \cdot D + p \cdot A\right] + \left[1 - \phi(H)\right]\left[p \cdot D + (1 - p) \cdot B\right] \\
= 0.5 \cdot D + 0.5 \cdot A + 0.5 \cdot D + 0.5 \cdot B \\
= 0.5 \cdot [D + A]
\]

and:

\[
E\Pi_{\text{USSR}}[\phi(D)] = \phi(D)\left[(1 - p) \cdot C + p \cdot B\right] + \left[1 - \phi(D)\right]\left[p \cdot C + (1 - p) \cdot A\right] \\
= 0.5 \cdot C + 0.5 \cdot B + 0.5 \cdot C + 0.5 \cdot A \\
= 0.5 \cdot [C + B]
\]

The overall payoff the pool on threat strategy therefore is:

\[
E\Pi_{\text{USSR}}(\text{pool on } T) = p \cdot [0.5 \cdot (D + A)] + (1 - p)\left[0.5 \cdot (C + B)\right] \\
= 0.5 \cdot [0.5 \cdot (D + A)] + 0.5 \cdot [0.5 \cdot (C + B)] \\
= 0.25 \cdot (A + B + C + D)
\]

This is the generic payoff function for the deterrent strategy of pooling on threats.

(B) Pooling on Mollify: The pool on threat strategy represents the prescription of spiral theorists, who argue that threats precipitate crises rather than prevent them. A state therefore will send mollifying
signals irrespective of its type. We can represent this strategy as:

\[ \phi(H) = 0 \]
\[ \phi(D) = 0 \]

As with the pool on threat strategy, this strategy provides player two with no information about player one’s type. We therefore must calculate player two’s posterior belief. After doing so, we then calculate player two’s expected payoffs for each possible outcome:

\[ E\Pi_{USSR}[\phi(H)] = \phi(H)[q \cdot D + (1 - q) \cdot A] + [1 - \phi(H)][(1 - q) \cdot D + q \cdot B] \]
\[ = 0 \cdot [0.5D + 0.5A] + 1 \cdot [0.5D + 0.5B] \]
\[ = 0.5(D + B) \]

and:

\[ E\Pi_{USSR}[\phi(D)] = \phi(D)[q \cdot C + (1 - q) \cdot B] + [1 - \phi(D)][(1 - q) \cdot C + q \cdot A] \]
\[ = 0 \cdot [0.5C + 0.5B] + 1 \cdot [0.5C + 0.5A] \]
\[ = 0.5(C + A) \]

The overall expected payoff of the pool on mollify strategy is:

\[ E\Pi_{USSR}(\text{pool on } M) = p[0.5 \cdot (D + B)] + (1 - p)[0.5 \cdot (C + A)] \]
\[ = 0.5 \cdot [0.5 \cdot (D + B)] + 0.5 \cdot [0.5 \cdot (C + A)] \]
\[ = 0.25 \cdot (A + B + C + D) \]

This is the generic payoff function for the tension-reduction strategy of pooling on mollifying signals.

(D) \textit{Proof:} We now have the generic payoff functions for the separating strategy, the deterrent strategy, and the tension reduction strategy. With these generic functions we can prove that there are no values for the payoffs that will allow either pooling strategy to dominate the separating strategy without violating our assumption of ordinality.

If the deterrent strategy were to dominate the separating strategy, its payoff function would produce a higher payoff than that of the separating strategy. Hypothetically:
\[0.25 \cdot (A + B + C + D) > 0.5 \cdot (A + C)\]

\[A + B + C + D > 2A + 2C\]

\[B + D > A + C\]

By our assumption of ordinality, however, \(A\) is greater than \(B\) and \(C\) is greater than \(D\). Hence the sum of \(A\) and \(C\) will always be greater than the sum of \(B\) and \(D\). The deterrent strategy therefore can only dominate the separating strategy if the order of payoffs is changed. This holds true as well for the tension reduction strategy of pooling on mollifying signals, since it’s generic payoff function is mathematically equivalent to that of the deterrent strategy’s generic payoff function. ∴

(E) Interpretation: This proof demonstrates that given the assumption of ordinality, neither the deterrent strategy nor the tension-reduction strategy dominates the separating strategy. This begs the question, however, of the ordering of payoffs in the crisis bargaining game. If we dropped the assumption of ordinality, might one of the pooling strategies then dominate?

As the proof above demonstrates, this is mathematically possible with a reordering of payoffs. Any reordering of payoffs would violate, however, our common-sense expectations for a state’s valuation of outcomes from crises. For instance, if we reversed the worst and second to worst payoffs \((C\) and \(D)\) we could allow either the deterrent strategy or tension-reduction strategy to dominate the separating strategy. In the crisis bargaining game this is analogous, however, to stating that states prefer nuclear war to the consequences of fighting a dove. Such an interpretation of state interests strains credulity. Of course, one might argue that it is the assumption of nuclear war which drives this finding. In other words, if the game seeks to model a state’s choice between two types of warfare other than catastrophic nuclear war, either the deterrent strategy or the tension-reduction strategy might outperform the separating strategy. Such an argument is not easy to dismiss. This supposition requires, however, a game theorist to make nuanced interpretations about a state’s indifference between two types of conflicts. Such interpretation is best left to empirical investigation, not formal modeling.

A second possible reordering of payoffs would also allow the deterrence or tension-reduction strategies to dominate the separating strategy. By reversing the best and second-best payoffs \((A\) and \(B)\) again it is mathematically possible. Such a reversal would violate, however, our rational-choice assumptions about state types in the crisis signaling game. Recall that we specified that doves prefer to send mollifying signals and hawks prefer to send threatening signals, but both prefer peace to conflict. A reversal of the best and second-best payoffs is the equivalent of saying a hawk prefers to mollify than to threaten. Likewise, such a reversal is equivalent to saying a dove prefers to threaten than to mollify. These are violations of the crisis signaling game’s construction of state types.

Short of a radical reconceptualization of the crisis signaling game, a reordering of the payoffs does not offer any circumstances in which the deterrence or tension-reduction strategies outperform the separating strategy. This leaves the modeler with only one other variable to consider: the probability \(p\) which nature selects state types. As shown in section 2.2 of appendix A, at the extreme values of \(p\)
= 1 and \( p = 0 \) we can see that the deterrent and tension-reduction strategies produce payoffs that equal that of the separating strategy. This tells us nothing theoretically useful, however, about the debate between deterrence and spiral theorists since their principal disagreement is about the nature of states in the international system—or alternatively, what the value of \( p \) really is. Deterrence theorists tend to see an international system populated by hawks, or a relatively high \( p \), while spiral theorists see fewer hawks in the system, or a lower \( p \). What is clear, however, is that for values of \( p \) between the extreme values of zero and one, the separating strategy dominates both the deterrent strategy and the tension-reduction strategy of spiral theorists. This demonstrates that both theories’ principal findings flow logically from their assumptions about state types—they are mathematically tautologous. Both theories need to respecify their explanations for state behavior in a world populated both by hawks and doves.
Works Cited


