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The neurobiology of hatred: Tools of Dialogue© intervention for youth reared amidst intractable conflict impacts brain, behaviour, and peacebuilding attitudes

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Abstract

Myths, drama, and sacred texts have warned against the fragile nature of human love; the closer the affiliative bond, the quicker it can turn into hatred, suggesting similarities in the neurobiological underpinnings of love and hatred. Here, I offer a theoretical account on the neurobiology of hatred based on our model on the biology of human attachments and its three foundations; the oxytocin system, the "affiliative brain", comprising the neural network sustaining attachment, and biobehavioural synchrony, the process by which humans create a coupled biology through coordinated action. These systems mature in mammals in the context of the mother–infant bond and then transfer to support life within social groups. During this transition, they partition to support affiliation and solidarity to one's group and fear and hatred towards outgroup based on minor variations in social behaviour. I present the Tools of Dialogue© intervention for outgroup members based on social synchrony. Applied to Israeli and Palestinian youth and implementing RCT, we measured social behaviour, attitudes, hormones, and social brain response before and after the 8-session intervention. Youth receiving the intervention increased reciprocity and reduced hostile behaviour towards outgroup, attenuated the neural marker of prejudice and increased neural empathic response, reduced cortisol and elevated oxytocin, and adapted attitudes of compromise. These neural changes predicted peacebuilding support 7 years later, when young adults can engage in civil responsibilities. Our intervention, the first to show long-term effects of inter-group intervention on brain and behaviour, demonstrates how social synchrony can tilt the neurobiology of hatred towards the pole of affiliation.

KEYWORDS
attachment, empathy, hatred, inter-group conflct, intervention, oxytocin, social neuroscience

Abbreviations: AT, Implicit Association Test; AVP, arginine vasopressin; EEG, electroencephalography; HPA, hypothalamic–pituitary–adrenal; MCC, medial cingulate cortex; MEG, magnetoencephalography; OT, oxytocin; RCT, randomised controlled trial; RL, right lingual gyrus; VTA, ventral tegmental area.

> The ancients placed love and war in the hands of closely related gods
>
> John Steinbeck, *Travels with Charley: In Search of America*

1 | INTRODUCTION

The inextricable knot between love and hatred has been well articulated since the ancient tale of Cain and Abel. Myths, scripture, drama, and sacred texts throughout the ages have warned against the fragile nature of human attachments; the closer the affiliative bond, the more it is prone to turn into hatred, aggression, jealousy, intrigue, suspicion, and even murder. Greek drama is replete with fathers, brothers, close friends, and fellow soldiers becoming, in a heartbeat, each other's worst enemy, as echoed by the famous "Et tu, Brute?" Even maternal love, the most sacred symbol of eternal devotion, can lead to murder, as depicted by Euripides' Medea. Humans may discard old affiliations not only for the development of new ones but also for commitments to a variety of Gods, Gurus, or Grand Causes, from "workers of the world" to transcendental meditators. The formation of a new attachment may be triggered by hatred to an old love, affiliative bonds can turn sour, and even a lasting and generally benevolent relationship often involves moments of pure hatred that, after passing, leave partners wonder at the intensity these moments elicit. Love and hatred seem to be closely intertwined and the split between them stems more from the human need to keep these two intense emotions apart than from the day-by-day reality of long-term attachments. The long-told story of human bondage appears to contain more than the vicissitudes of love.

Still, while human love and hatred have been depicted by any possible art form; poetry, literature, drama, dance, painting, sculpture, and cinema, the scientific foundations of love, and even more so of hatred, have not yet been described. In the following, I address the neurobiological underpinnings of love and hatred and discuss how the three tenets of the "biology of love" proposed by our model[1–3] can turn into hatred very quickly when fear prevails. Since the biology of love relies on ancient systems that support bond formation in mammals – altricial young born with immature brain who require maternal presence and caregiving behaviour to develop neurobiological systems that enable life in the social ecology – systems that sustain maternal care have become very sensitive to minor variations in social behaviour.[3,4] Upon detection of such minute differences, all alarm systems are activated and trigger the fear response that prepares the body – brain, muscles, autonomic system, hormones, and behaviour – for the "fight of flight" response. While activating such widespread and energetically costly response to minute variations in social behaviour may be overkill, the alternative, a complex response that requires time and brain space, is more evolutionarily risky and when the stakes are so high, why take a chance? The systems underpinning affiliation and stress management are ancient and evolved to respond automatically to any sign of danger.

Key Notes

- Our behaviour-based model contends that love and hatred are underpinned by the same neurobiological foundations, which connect individuals to in-group and demarcate outgroup.
- A neuroscience-informed synchrony-enhancing intervention implemented to Israeli and Palestinian youth improved social behaviour, oxytocin and cortisol, conflict attitudes, and the neural empathic and prejudice response, and predicted peacebuilding involvement seven years later.
- Our intervention focusing on affiliation, empathy, and dialogue can apply to multiple settings of inter-group conflict.

Variations that can distinguish real from imaginary danger or social behaviours that spell true risk from those that are simply unfamiliar, culture-specific, or odd require top-down processing that takes time and energy, resources the animal does not have when danger is imminent. The systems of love-turn-hatred are automatic and quick-to-activate and, most importantly, are behaviour-based and triggered by social behaviours that are not identified as belonging to "our clan".

2 | THE THREE TENETS OF THE BIOLOGY OF HUMAN ATTACHMENTS

Consistent with our model,[1–3,5] I suggest that the evolution of mammals implied that systems that sustain stress management, adaptation, and endurance no longer developed in the young in the context of the group, as was the case in fish, birds, or ants, but mature in the young mammal within the intimacy of the mother–infant bond; hence, systems that support resilience first develop through well-adapted caregiving and then transfer to enable life in the social ecology. During that critical shift from the mother–infant bond to life within social groups, these systems partition to support both love and hatred by cementing the bond to one's own group but, at the same time, clearly demarcating the in-group from the out-group and consolidating one's perception of the outgroup as frightening, dangerous, and worthy of destruction. This double-edged perception is engraved into the young animal's brain and neurobiological systems and, from this perspective, one may argue that the capacity to "hate" (i.e., demarcate, fear, and prepare to destroy the "outgroup" whose social behaviour is different, strange, or scary) enables the biological possibility of "love" (i.e., forming lasting bonds to both exclusive others and larger social groups). Our model is depicted in Figure 1 and describes the three foundations of the biology of love – as well as hatred: the oxytocin system, the "affiliative brain", that is, the neural attachment network, and biobehavioural synchrony.

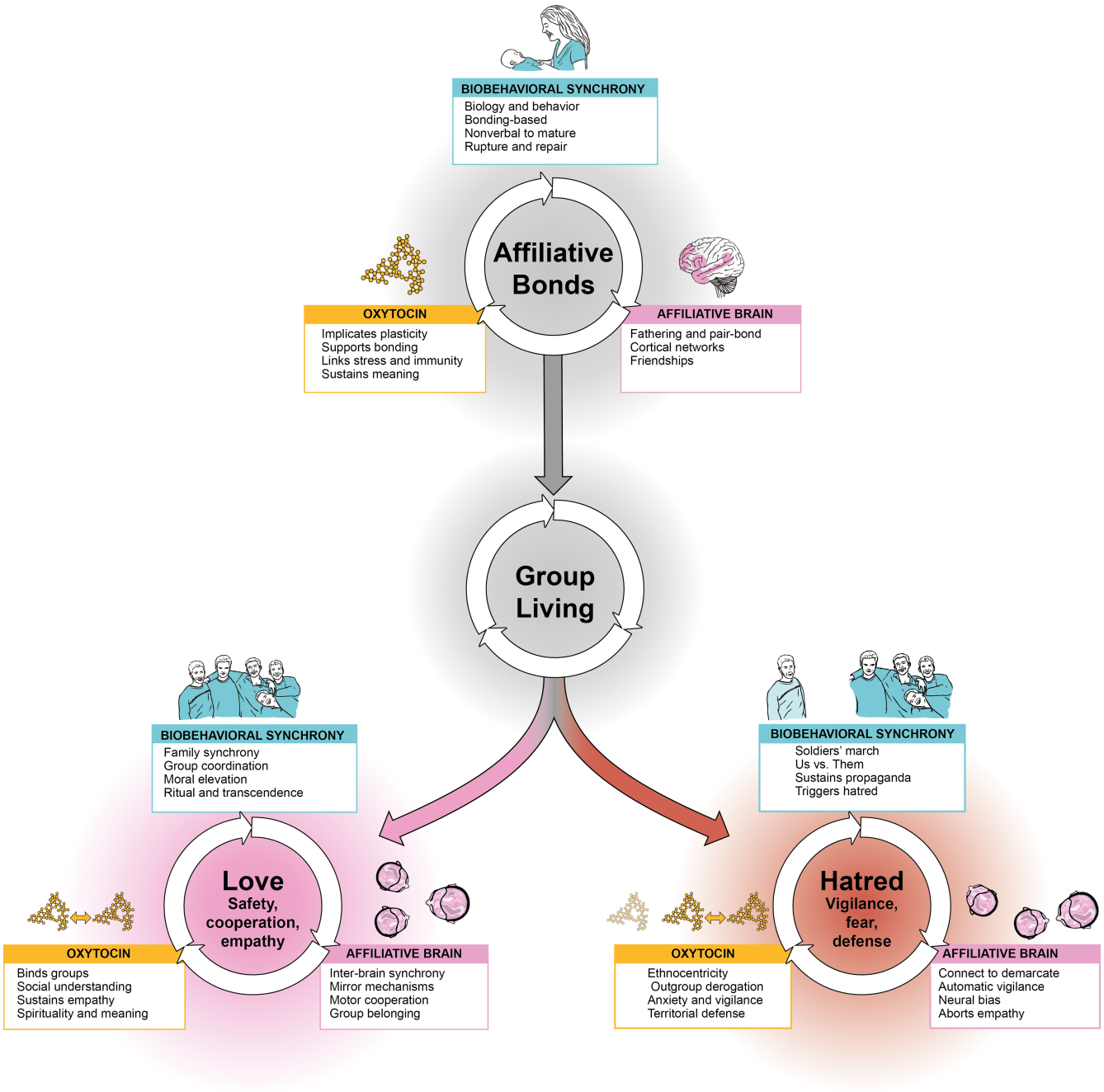

FIGURE 1 The transition from affiliative bonds to group living partitions into the neurobiology of love and hatred. Figure describes how the three foundations of the biology of attachment – the oxytocin system, the affiliative brain, and biobehavioural synchrony – mature in the context of the mother–infant bond and then transfer to support life within social group. During this transition, these systems partition to support love, empathy, cooperation, and compassion towards members of the in-group while simultaneously underpinning vigilance, fear, demonisation, and hatred towards the outgroup on the basis of minor variations in social behaviour.

2.1 | Oxytocin

The initial role of the oxytocin (OT) system, an ancient molecule evolved approximately 500 MYO and found in all vertebrate and some invertebrate species, was to help organisms manage life in harsh ecologies; hence, OT supports the regulation of basic life functions, such as water conservation, energy balance, or thermoregulation. With the evolution of mammals, OT became causally involved in the mammalian condition by controlling uterine contraction, milk letdown, and the initiation of maternal behaviour.[6,7] OT is the system that sustains affiliative bonds, and studies in animals[8–10] and humans[11] pointed to its involvement not only in parental care[12] but also in pair bonding and filial attachment (friendship), underscoring its key role in human love.

Oxytocin implicates plasticity at the cellular, molecular, and network assembly levels,[13–15] playing an important role in resilience that requires flexibility.[2] OT is an integrative system that cross-talks

with the stress, reward, and immune systems, integrates body and brain, and its receptors are widely distributed throughout the body.[6,16–18] Furthermore, OT integrates the individual with its environment through its epigenetic nature and its maturation via a chain of environmental influences.[19,20] Importantly, OT functions as a bio-behavioural feedback loop; more synchronous behaviour, touch, and contact trigger OT release,[21] which, in turn, strengthen affiliation, empathy, and collaboration. This feedback loop constitutes a key component of our model. Since the OT system is behaviour based and can be triggered by coordinated social behaviour, interventions that increase behavioural synchrony may function to elevate OT production, enhancing its benevolent effects.

Finally, OT supports human love through its involvement in higher order human capacities that enable affiliation. OT is implicated in empathy, theory of- mind, and the capacity to accurately perceive and share others' emotions (empathic accuracy).[22–24] OT has also been suggested underpin the "meaning" dimension in human resilience by sustaining spirituality and the sense of transcendence,[25] possibly through its anxiolytic effects[26] and its impact on blurring the distinction between self and other,[27] thus creating the states that provide the neurobiological basis for love.

2.2 | The affiliative brain

The neural network that supports our capacity to form and maintain human attachments are built on the ancient subcortical structures that sustain maternal caregiving in mammals.[28,29] Primed by the hormones of pregnancy, particularly OT and prolactin, the medial pre-optic area of the hypothalamus sends projections to both the amygdala, to increase maternal vigilance of infant safety, and the VTA, a key node of the subcortical dopamine network, to create a subcortical system that underpins maternal caregiving. This subcortical network consolidates through active caregiving and enables mammalian mothers, from rats to elephants, to recognise, invest, nurse, comfort, and provide a secure habitat for their offspring.

Still, to parent human children and prepare them to the complexities of human social life, parents' brain must contain higher order structures. Imaging studies of the parental brain have shown that the subcortical structures are connected via multiple ascending and descending projections to networks that sustain empathy, mentalisation, and emotion regulation structures[30–32] and the two parts, the ancient and more recently evolved structures cohere into a global "human attachment network". Furthermore, due to the parsimony principle of evolution, this same network evolved to sustain other forms of love, including pair bonding and friendship.[1] Notably, this same network also supports humans' abstract attachments; to God, homeland, arts, the biosphere, and abstract commitments to which the individual is wholeheartedly attached. Like the OT system, the human attachment network is triggered by synchronous social behaviour in a feedback-loop manner.

BOX 1 The transfer to sociality via affiliation, cooperation, empathy, and love.

The three foundations of the biology of love enable humans to form affiliations to social groups that range from small and concrete (e.g., family) to large and abstract (e.g., nation) and create a sense of safety, sustain the formation of meaning systems through belonging to cultural/social traditions, and instill calmness and trust. These establish the neurobiological state that supports love.

1. *Oxytocin* has been linked with cooperation in primates,[81] with amicable conflict resolution in chimpanzees,[82] and with cooperative breeding in rodents,[83] indicating its role in coordinating members of a species into a task-oriented group. In humans, OT is implicated in higher order processes that enable joint actions and collaboration, including empathy,[84] understanding others' mind,[85] and forming group cohesion,[86] as well as in processes that enable a sense of meaning that sustain bonding to one's social group, including spirituality[25] and a sense of transcendence.[87]

2. *The "affiliative brain"* comprises the neural network that underpins attachment. It builds on the subcortical structures that sustain the mammalian maternal brain that expanded in humans to include higher order networks of empathy, embodiment, and emotion regulation. This attachment network further expanded to support an increasing circle of affiliations; to partners, friends, mentors, co-workers, and countrymen, as well to abstract commitments that give meaning to life. Nodes of the human attachment network are also implicated in processes of brain-to-brain synchrony.[88,89] Inter-brain synchrony binds us neutrally to others and the degree of inter-brain synchrony increases when partners are within a loving relationship, such as parents and children,[36,90] romantic partners,[89] or close friends,[88] indicating that the affiliative brain binds us to those we love.

3. *Biobehavioural synchrony*, the coordination of biology, and behaviour during social contact functions as the "glue" that binds members into social groups. Moments of behavioural synchrony, such as shared gaze of joint laughter, provide the template for the coordination of physiological processes.[89] Synchrony sustains the sense of transcendence, consolation, and moral elevation experienced during cultural rituals, religious ceremonies, and sacred dances, which have accompanied the history of *Homo sapiens* since the dawn of civilisation.

2.3 | Biobehavioural synchrony

Similar to the first two tenets, *biobehavioural synchrony* relies on ancient roots; the coordination of biological and behavioural events during social group processes that are observed ants, fish, or birds when coordinating movement to execute a survival-related goal, such as carrying a grain of wheat to shelter or flying to warmer climates. With the evolution of mammals, *biobehavioural synchrony* became linked with the mother–infant context and is defined as the "coordination of biology and behavior between parent and child during moments of social contact".[5,33] Moments of synchrony in mother and infant's social behaviour, such as gaze, positive affect, co-vocalisation, or joint movement, provide a template for the coordination of physiological processes, such heart rhythms,[34] hormonal release,[35] and brain-to-brain synchrony,[36] providing the mechanism by which the mature brain externally regulates the immature brain to social living.

Importantly, *biobehavioural synchrony* undergoes substantial maturation across human development and the non-verbal exchange of infancy expands to include symbolic expansion, empathic dialogue, and the discussion of multiple perspectives, until mother and child can meet each other in a respectful mother–adult–child dialogue that is built on autonomy and mutuality. The process also expands to other affiliative bonds and social relationships and is found between romantic partners, friends, mentors, therapists, and even strangers.[37] As *biobehavioural synchrony* links biology and behaviour in a tightly coupled manner, we expected that introducing synchronous activities between outgroup members may trigger the biology of affiliation which, in turn, increases empathy, trust, and cooperation through an ancient, bottom-up, behaviour-based mechanism.

3 | THE NEUROBIOLOGY OF ATTACHMENT PARTITIONS INTO LOVE AND HATRED DURING THE TRANSFER FROM MATERNAL–INFANT BONDING TO LIFE WITHIN SOCIAL GROUPS

While the three foundations of the "biology of love" support the transfer to social life, this process is complicated and acts as a double-edge sword. During the transfer from the safe haven of maternal care to affiliations that involve an increasing circle of family, friends, neighbours, and countrymen to which the child is gradually introduced, the demarcation between in-group members, those the infant learns to trust and eventually identify with, and out-group members, whom he/she is taught to fear, suspect, and eventually repudiate, becomes a key issue in the child's socialisation process. In societies that are rigid, under siege, or involved in a long-lasting war over resources, religions, or customs, this process is brought to an extreme focus and the "outgroup" is especially demonised. The argument being forwarded here is that the demarcation of friend from foe that is transmitted to young children through myriad of verbal and nonverbal signals is integrated into the child's brain and neurobiological systems and rides on the same processes as those which sustain affiliation to the social group. Such deep-seated and non-conscious internalisation is very difficult to untangle.

In this context, the conceptual model of Sue Carter,[17] among the first researchers on the role of the OT molecule in mammalian bonding and its relevance to human love,[38] is illuminating. Carter suggests that oxytocin may operate via OT receptors and in such cases it functions to induce calmness, have an anxiolytic effect, and enhance the sense of equilibrium, creating a state that Carter and Porges call "immobility without fear"[39(p156)] that supports the formation of attachment bonds. Conversely, OT may work through the receptors of its sister molecule, arginine vasopressin (AVP), a system associated with male bonding, territorial defense, and aggression that is closely linked with the HPA-axis.[40] AVP triggers heightened vigilance, motivation to defend loved ones against potential danger, and preparation of body and brain to the fight-or-flight response.[17] It is possible that these two pathways by which OT operates are expressed in the love and hatred duality the system supports; the love pathway is preserved for those belonging to the family, village, or tribe, while the hatred pathway applies to those perceived as dangerous, "infidels", or outgroup members who require constant vigilance else they may hurt the safety of our loved ones. The most difficult-to-amend, survival-related feature here is that both are activated simultaneously during the formation of affiliative bonds. Boxes 1 and 2 describe the role of the three foundations of the biology of attachment in support of love (Box 1) and hatred (Box 2).

4 | "TOOLS OF DIALOGUE"©: AN INTERVENTION FOR YOUTH REARED AMIDST INTRACTABLE CONFLICT

Based on our model[1,2] and the understanding that love and hatred are built on the same neurobiological systems that support bond formation in mammals and can quickly switch when social behaviour is perceived as dangerous or even merely foreign[2,3] we built a synchrony-based intervention for Israeli and Palestinian youth (Figure 2). We chose to target the age of 16–18 years, as this is a time when youth are highly susceptible to propaganda and are easily influenced by charismatic leaders that offer hateful rhetoric and the illusion of belonging to a tightly knit group. At the same time, late adolescence is the period when abstract thought and cognitive empathy mature and adolescents can appreciate multiple perspectives, rendering the effort to see the perspective of the "enemy" developmentally plausible. Guided by models that mark adolescence a time of brain reorganisation, which leads to heightened vulnerability alongside increased opportunities for social change,[41,42] our 8-week dialogue-enhancing group intervention targeted Israeli and Palestinian youth who mark a fourth generation reared in a climate of intractable conflict and intense hatred.

The intervention was informed by our conceptual framework of *biobehavioural synchrony*[2,5,33] and focused on synchronous actions, actual conversations, affiliative familiarisation, and knowledge on

BOX 2 The transfer to sociality via fear, derogation, destruction, and hatred.

The three foundations of the biology of love, while binding individuals to their loved ones and cementing their belonging to social groups, also function to demarcate "friend" from "foe", increase fear of the "other" based on minor variations in social behaviour, and dehumanise the "enemy" as worthy of destruction.

1. *Oxytocin*. Studies have shown that oxytocin, which sustains bonding and compassion, also underpins ethnocentricity and outgroup derogation.[91] Even during economic games, which are clearly remote from real danger or inter-group struggle, intra-nasal oxytocin administration enhances competition between those perceived as "us" versus "them", even when differences are between those who wear a blue or red shirt or those initially tagged as "in-group" versus the "competition".[92]

2. *The "affiliative brain"*. In the context of ongoing conflict, individuals tighten interbrain synchrony in nodes of the affiliative brain to in-group members and such neural coupling functions to increase outgroup derogation and enhance hostility. Furthermore, the neural mechanism that supports empathy is aborted in mid-way when pain is inflicted to those perceived as "outgroup".[49]

3. *Biobehavioural synchrony* can serve as a powerful method of outgroup derogation and hatred. The ancient mechanism of *biobehavioural synchrony* that sustains group cohesion in ants, fish, and birds has been utilised by humans not only for cooperation and sharing but also for the training of soldiers to coordinated actions that enable humans to disconnect action from their moral components, execute orders without compassion, and impart pain on the "enemy".[4] Throughout history, humans have used the coordinated marching of soldiers not only to instill loyalty to king and country but also as a potent threat to those who may attempt action against the in-group. Charismatic leaders induce greater neural synchrony in their listeners[93] through masterfully applying the non-verbal building blocks of parent–infant synchrony; constant gaze, affective expressions, repeated vocalisations, joint exclamation, and exaggerated body movement, in the service of in-group/outgroup demarcation and a call for loyalty and derogation. Political rallies, soldier marching, story-telling, and synchronous chanting are often used not to increase transcendence but to build hatred. Such powerful synchronous actions are imprinted in the brains of young children and are very difficult to reverse.

the central obstacles, as well as the key behavioural components of respectful dialogue among warring parties. Before and after the intervention, which was implemented within a randomised controlled trial (RCT), we observed social behaviour during one-on-one interactions between out-group members, assayed stress (cortisol) and affiliation (oxytocin) hormones, imaged the brain basis of empathy and prejudice, and assessed adolescents' attitudes towards the conflict and their opinions on whether peace is possible and the pathways for reaching it. Seven years after the intervention, when youth were already young adults who can engage in civil duties and responsibilities, we returned to the participants and re-evaluated their opinions on the conflict and their attitudes towards participation in peacebuilding efforts.

In this context, it is important to note that while countless of interventions have been developed and implemented to enhance dialogue among outgroup members for nearly seven decades, since Allport (1954)[43] first introduced his famous "contact model", NO study has shown intervention effects on neural response. Furthermore, a recent review of 418 studies implementing a wide variety of brief and longer term interventions for multiple intergroup conflicts indicated that *none* showed an effect beyond several months.[44] Our intervention, therefore, is unique in its underlying behaviour-based conceptualisation, inclusion of neuroimaging measures, and the demonstration of long-term effects in the context of a century-long intractable conflict.

The manualised "Tools of Dialogue©" intervention[45] includes eight three-hour group sessions, was framed in the context of RCT, and implemented rigorous scientific guidelines. Groups comprised 10 or 12 participants, equally divided between Jewish and Arab participants, and included all-boys or all-girls participants to avoid potential sexual tensions or conflict with Jewish or Muslim laws. Each session tapped a specific topic that was considered a building block in our overall frame and the progress between sessions was well thoughtout (see Sections topics on Figure 2). Sessions were conducted by two moderators, one Jewish and one Arab who had extensive experience with Israeli-Palestinian dialogue groups, and participants could speak their native language with the moderator translation. This intended to avoid the need to speak Hebrew, the official language of the state, which may represent the "enemy" for the Arab participants, or in English, a language that was not fully mastered by youth, although often used during the sessions.

The entire study was conducted in the frame of an RCT [Clinical Trials Registry (NCT02122887)]. We recruited 118 youth, who were randomised to those who received the intervention and those who were matched for gender, age, and SES and served as controls. Before and after the intervention all participants, in both the intervention and control groups, underwent extensive testing. First, participants engaged in one-on-one interactions with in-group and out-group same-sex members in both positive and conflict interactions. Interactions were coded offline with our behaviour coding system,[46] which has been validated in a large number of studies

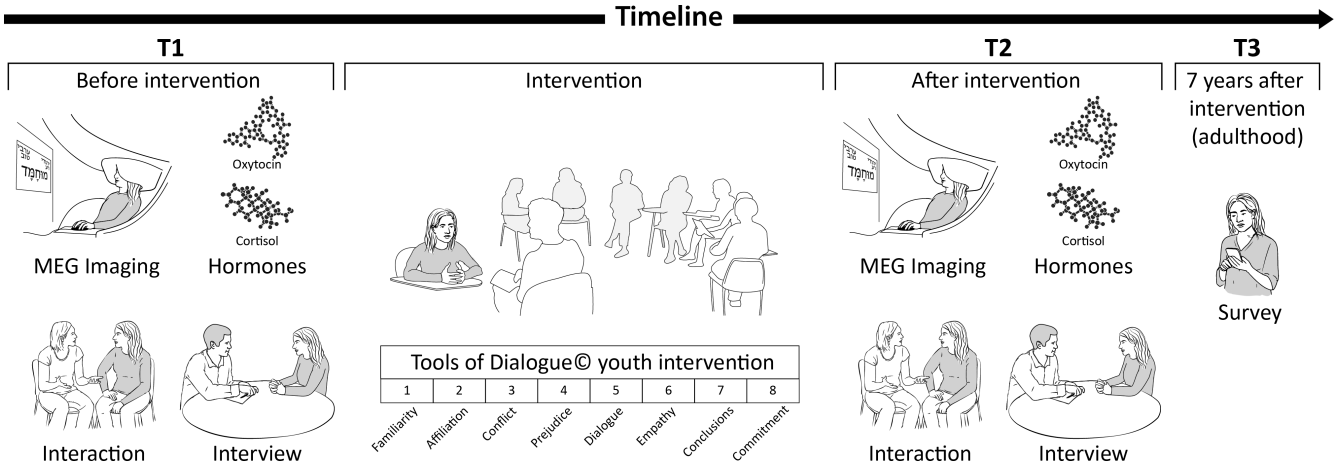

FIGURE 2 Randomised controlled trial investigating the effects of the Tools of Dialogue© intervention for youth reared amidst intractable conflict on social behaviour, hormones, brain function, and attitudes and on peacebuilding efforts in young adulthood. Before (T1) and after (T2) intervention, we observed and coded social interactions between Israeli and Palestinian adolescents (16–18 years), conducted in-depth interview on the conflict, assayed oxytocin and cortisol, and measured the brain basis of empathy and prejudice. Seven years after the intervention, we examined young adults' (24–25 years) attitudes towards peace and active participation in peacebuilding efforts.

across 27 countries in samples ranging from infancy to adulthood,[47] and coders were blind to the participant's group membership (intervention, control). We focused on the constructs of reciprocity, hostility, and empathy that tapped how the adolescents conduct their social interactions with outgroup members, particularly since for most, this was the first time they met an adolescent from the other side. During the videotaped interactions, adolescents wore devises that collected online physiological data (ECG and skin conductance) to assess the degree of physiological stress.

Next, we conducted in-depth interviews with each adolescent that considered their views on the roots of the conflict, thoughts about the chances for peace, willingness to be involved in peacebuilding efforts, ability to see the narrative of the other side even without accepting it, and thoughts on what is required from each side to make peace possible. Here, we hoped that the intervention would strengthen the adolescents' commitment to peacebuilding and their ability to see multiple perspectives and acknowledge that both sides have a hand in the current stalemate.

Following, each participant underwent brain imaging using magnetoencephalography (MEG) to assess the brain basis of empathy and prejudice. We employed a variation of the well-validated "empathy for pain" paradigm[48,49] and a neural adaptation of the famous Implicit Association Test (IAT).[50] Empathy is a key ability that has received extensive research in social neuroscience.[51,52] Prejudice is a core unconscious feature of social group living that prevents inter-group dialogue and researchers on the neuroscience of intergroup conflict have emphasised the need to understand the brain basis of prejudice[53] and its involvement in sustaining tenacious conflicts. Finally, at baseline and after interaction, interview, and before and after the brain imaging, we collected five saliva samples that were assayed for oxytocin and cortisol. Participants also completed self-report measures related to empathy, attachment, and mental health. Overall, our effort marks the first extensive neuroscience-based assessment of the effectiveness of an inter-group intervention that includes neural, physiological, hormonal, and behavioural components.

5 | IMPLEMENTING THE TOOLS OF DIALOGUE"© INTERVENTION

Based on the *biobehavioural synchrony* frame, we began and ended each session with synchronous or ritualised acts, such as folk songs that involved movement in Hebrew or Arabic, joint drumming, which is known to have a soothing effect in times of stress,[54] reading of poetry in either language, or reciting from the Bible or Koran in Hebrew and Arabic. After the introduction of the session topics, sessions continued with specific group activities that were designated for each session and involved either one-on-one interaction, tasks for small groups that were composed of Jewish and Arab members and needed cooperation from members who then presented their efforts to the entire group, or whole-group discussions on selected topics, at time in a form of games or special tasks. We began and ended each session in ritualised, joint, and synchronous actions to induce positive energy, acceptance, and cooperation and to stimulate the biology of love.

As seen in Figure 2, the first two sessions were devoted to familiarity and affiliation, with the goal of reducing the stress response that prevents "true" meeting of the other. In the first session, each adolescent introduced him/herself; the things they "like to do", hobbies, hopes for the future, conflicts, identification with cultural heroes or sports team, personality traits, and sources of difficulty (e.g., math, conflict with parents, looks). The moderators made a special effort to draw parallels and show that youth, regardless of where they come from, have much in common and are preoccupied with

the same issues and this immediately reduced the sense of alienation upon which propaganda leaders build the fear of the other. The second session focused on the adolescents' relational matrix and asked participants to discuss their circle of affiliations; siblings, family, neighbours, and culture. Youth described what they love about their cultural costumes, such as special foods, music, or holidays, and how these are celebrated in their home. This enabled other members to familiarise themselves with the home and cultural niche, bring the "enemy" to life, and humanise the other, and this served as the first step towards tilting the biology of hatred towards the pole of love.

Following the familiarisation sessions, the next four sessions were each devoted to a specific pre-selected topic presented in the beginning of the session. We explored key topics that enhance a positive dialogue between parties within a deep-seated conflict and those that prevent a respectful dialogue in conflictual contexts; sessions 3 and 4 dealt with "conflict" and "prejudice", while sessions 5 and 6 were devoted to "dialogue" and "empathy". These sessions explored each topic through games, actions, one-on-one interactions, and joint group tasks and discussions. For instance, youth discussed what is a "conflict" – between family members, within communities, and among nations – how conflicts express behaviourally and how can conflicts be dialogued with empathy. We discussed how to dialogue conflicts in ways that are respectful and productive, and, while not fully accepting the position of the other side, how to create an atmosphere that understands where the other comes from. The next session explored the explicit and implicit components of prejudice, how can one identify such deep-buried and often non-conscious biases, and what strategies can be used to combat the tenacious nature of prejudice.

The more positive components of social dialogue were addressed in the next two sessions. The "dialogue" session examined the behavioural features required to create a respectful dialogue in which each person expresses his/her position but also truly listens to the other. The session on empathy tapped the question of "what is empathy", how empathy develops, and how one can cultivate empathy in the context of a log-term conflict with no resolution in sight.

Finally, the last two sessions considered how youth can make room for the insights gained during the intervention in their daily lives. The last meeting included a metaphorical "gift giving". In the next-to-last meeting, the moderators asked each participant to prepare a "gift" to the group with the notion that each will give the element they found most meaningful and that the act of giving to the group may be a powerful act that can change the biology of hatred back to its affiliative matrix. Overall, all participants described the intervention as eye-opening and personally significant, albeit the degree to which it changed their attitudes and willingness to engage in peacemaking varied.

6 | EFFECTS OF THE TOOLS OF DIALOGUE"© INTERVENTION ON YOUTH SOCIAL BEHAVIOR, HORMONES, AND ATTITUDES

Significant effects for the intervention were noted in each of the four dimensions tested: social behaviour, hormones, brain, and attitudes. For all components, we found no differences between the intervention and control groups at the pre-intervention testing (Time 1; T1), indicating a true randomisation. In contrast, on most variables tested, we found a significant difference between the intervention and control groups after the intervention (Time 2; T2), suggesting a broad-band effect for our synchrony-based dialogue-enhancing intervention.

6.1 | Social behaviour

Participants were asked to engage in a 7-min one-on-one conflict discussion with an outgroup member and could choose any conflict, whether personal and national. While the intervention did not alter social behaviour related to level of engagement, creativity, elaboration, or complexity of narrative, it changed three key features linked with the manner in which individuals from antagonistic groups discuss conflict; reciprocity, hostility, and empathy. *Reciprocity* is a key feature of social interactions that taps the give-and-receive dimension in the social exchange, the degree to which it is built from the input of both partners, and how the participants weave together the fabric of the social dialogue with fluency and mutual adaptation. Reciprocity is a non-verbal component of the interaction that is learned within the parent-infant bond and is individually stable in both the mother–child and father–child relationship from infancy to adolescence.[55] Although interactions at this stage are verbal, the non-verbal aspect of reciprocity taps the underlying flow, relational dynamics, and joint attunement of their social experience. We found that at T2, adolescents who received the intervention showed significantly more reciprocity compared to controls and that their reciprocity increased significantly from T1 to T2, reflecting the greater ease, familiarity, and trust with which they can meet the "enemy" after the intervention.[56]

In addition, we found a significant decrease in *hostility* for the intervention group at T2. Hostility is expressed through both verbal and non-verbal social cues such as sarcasm, negative facial expressions, down-putting, aggressive words, condescendence, or hostile comments and movements. Hostility is often accompanied by felt tension between partners and the constriction of their dialogue and the decrease in hostility signals a change in the participants' willingness to put a human face to the enemy and not only derogate. Finally, we saw an increase in dialogical *empathy* at T2 for the intervention, but not the control group. Empathy contains two components – an emotional component that is automatic and is expressed as resonance with the pain, distress, or positive feelings of the other, and a cognitive component, which is top-down, places the other's feelings in context, and plans a way to help the other's distress.[51] The increase in empathy at T2 for the intervention participants who were aware of the two-tier nature of empathy was expressed in their non-verbal behaviour, including attention to the other's signals, welcoming facial expressions, and exclamations such as "it must have been very difficult", as well as in the cognitive aspects of empathy, such as putting the other's emotions in a greater context, finding parallels to one's own experience, and suggesting potential

pathways out. We also found that for the intervention group at T2, most conversations (67%) focused on the national conflict, whereas at T1 only about 30% of the discussions centred around this touchy issue, indicating that for those who underwent the intervention, discussing the national conflict with members of the other side became a more viable option that can be handled with respect despite opposing opinions. We consider this a key success of the intervention. As these adolescents grow and become citizens, they must learn to dialogue the national conflict with respect and empathy in order to increase the future prospects of peace.

6.2 | Affiliation and stress hormones

In five saliva samples collected during the extensive day of testing, we assayed the overall production of oxytocin and cortisol (CT) before (T1) and after (T2) the intervention. Our hypothesis, that OT will increase and CT decrease for the intervention group was partially supported. We found that OT production increased for the intervention group, but only for those who increased their capacity to hold multiple positions and changed their perspective, that is, they were able to see the other's position, understand their fears and struggles, and, while not justifying their behaviour, contemplate the reasons for it. In short, those who showed plasticity in their deep-seated beliefs also increased OT levels following the intervention when meeting members of the out-group. OT is a biomarker of plasticity,[1] and it is possible that youth with greater neural plasticity, whose OT system is initially more malleable, were more impacted by the intervention and were able to alter their perceptions, but this hypothesis requires further research.

In contrast to the findings for OT, we found that cortisol production decreased for all adolescents who underwent the intervention, but not for controls. Cortisol response to meeting with out-group members has been previously noted in encounters with outgroup, typically between races, such as black and white or Latino and white students, or between Canadian citizens versus Chinese immigrants.[57] The increase in HPA-axis activity following encounter with outgroup members reflects the fear of the demonised "other" that is typically nourished by unfamiliarity which provides a fertile ground for vigilance. The reduction of cortisol production in those who underwent the intervention, became familiar with the other side, and learned to dialogue with empathy, identify prejudices, and manage conflict with respect showed that they were able to meet the "enemy" without triggering a strong fight-of-flight response. Since the biology of hatred is built on fear, the attenuation of the endocrine fear response is an index of the true success of our intervention at the biological level. In this context, it is important to note that our intervention is the first to show a complex biological response to a youth-based intervention aiming to increase dialogue among out-group members and the findings show that our intervention went "under the skin" and expressed in biomarkers that are out of the adolescent's conscious control.

6.3 | Attitudes towards the conflict

We found intervention effects on two types of attitudes. First, following the intervention, adolescents were more willing to endorse multiple perspectives. While not moving from believing in the righteousness of their own group, they were able, after meeting the other side and hearing their story, to give some credibility to the others' narrative and contemplate that the blame for the long-term statement may reside in both parties. Second, we found intervention effects on the adolescents' belief that peace is possible, even if not in the near future, and on their willingness to engage in peacebuilding efforts. This is particularly important as youth represent the future generation of the country and their commitment to peacebuilding, if maintained, can become a great asset upon which a more just society may be built.

7 | EFFECTS OF THE INTERVENTION ON THE BRAIN BASIS OF EMPATHY AND PREJUDICE

7.1 | Empathy

Empathy is key feature of human sociality and the social function which received the most extensive neuroscientific research. To image the neural empathic response, we used a well-validated set of pictures that show hands and feet in physical pain (e.g., hand burnt by iron, foot stuck in door) as compared to identical pictures without the painful element, which have been validated in multiple studies to reliably elicit the brain's empathic response.[48] However, we added an important component to the paradigm. Before each stimulus, a screen announced the nationality of the protagonist; "This is Danny from Tel-Aviv", "This is Ahmed from Kafar Kara", and adolescents observed equal number of stimuli where pain is inflicted on ingroup or outgroup targets. Empathy to others' pain has been shown in multiple EEG, MEG, and fMRI studies to emanate from the sensori-motor cortex, potentially involving mirror mechanisms, and EEE/MEG studies pinpointed it to S1.[58,59]

Results were eye opening and described the mechanism humans use to inflict pain on the "enemy". We found that for the first 500 ms, representing the brain's automatic empathy response, youth responded equally to others' pain, whether it was inflicted on the ingroup or outgroup. Still, after this half-second of grace, the brain's top-down mechanisms began to shut down the neural empathic response to the outgroup while maintaining its typical activation to the pain of the in-group. This later, more cognitive empathic response is critical to create the higher-order empathic response that involves understanding of others' feelings, generating compassion, and forming a plan of helpful action. Aborting neural empathy at mid-way does not allow the brain to sustain a fully human response that can activate emotional resonance as well as cognitive understanding and future help. Shutting down

the brain's empathic response towards outgroup's pain allows humans to inflict pain on others, despite the strong neural resonance that prevents us from hurting others. We also found that greater OT production among Jewish participants and greater brain-to-brain synchrony among Arab participants increased alliance to the group and were linked with higher in-group neural bias (i.e., greater difference between the individual's neural response to the pain of in-group versus out-group protagonists), *highlighting how oxytocin and biobehavioural synchrony, components of the biology of love, can function in the service of hatred*.[49]

At T2, we clearly saw the double-edged neural response. For the controls, the same aborted response to the pain of in-group and out-group protagonists was observed. However, for the intervention adolescents who learned to include the "other" in their in-group, we saw a full human empathic response to the pain of outgroup. We contend that meeting the other in his or her humanness enabled adolescents, who have learned to appreciate both the emotional and cognitive components of empathy, to activate their full neural empathic response.[60] We believe that altering adolescents' brain response to outgroup is among the key successes of our intervention that highlights the deep-seated effects on the social brain during a critical period of its maturation.

7.2 | Prejudice

Prejudice is a non-conscious response to those who are unlike "us", which stems from humans' reliance on group living for survival that has led to a biased assessment of their social environment; members of one's social group (ingroup) are consistently perceived in more favorable terms as compared to members of other groups (outgroup).[61] The most widely used measure to evaluate implicit intergroup bias is the IAT, which has been implemented in thousands of studies.[62] This test relies on the slower behavioural response to incongruent (e.g., outgroup as "good") vs. congruent (e.g., outgroup as "bad") stimuli. This reaction time difference, measured in milliseconds, is termed the "IAT effect" and indexes the implicit bias the individual holds towards outgroups. The IAT has been used to investigate intergroup relations across the world,[63] including in the context of the Israeli-Palestinian conflict.[64–66] However, the neural underpinnings of the IAT, and with it of prejudice more globally, are not fully understood.[49,53,66–69]

Employing a variation of the IAT in Hebrew and Arabic in the MEG context, we found a consistent activation of the alpha rhythm throughout the IAT paradigm. The alpha rhythm, which is involved in emotional and cognitive processes,[70–72] emanated from the right lingual (RL) gyrus of the occipital cortex, a regions implicated in the early stages of visual perception that includes visual processing, logical conditioning, and visual memory.[73–75] This immediate and early component of the RL was complemented by a later component in the medial cingulate cortex (MCC), which indicates a top-down mechanism involved in social cognition, social evaluation, and cognitive control. Our findings are consistent with a previous study of the IAT using EEG, which showed that the only two regions that plausibly reflect the intergroup bias were the RL gyrus and the MCC, which occurred early and later, respectively.[76] These findings suggest that a sustained alpha at the RL combined with the MCC in response to the IAT serves as a neural marker of prejudice. This prejudice neural marker was negatively correlated with the adolescent's attitudes of belief in peace and with greater social engagement during interaction with outgroup members.[75]

Following the intervention, the neural prejudice response was no longer found for the intervention group, that is, alpha activity in the RL showed no differences between congruent and incongruent trials. This suggests that the personal meeting with members the out-group and the coordinated activity, as well as understanding the nature of prejudice and its potential hazards, impact youth not only at the behavioural level but also at the neural, non-conscious level.

7.3 | Long-term effects on adults' peacebuilding attitudes

The most important question to consider with regards to any intervention is its long-term impact. Outcome of *any* intervention to mitigate intergroup conflict has so far been very grim; no intervention has shown effects for more than several months, many yielded null results, most were poorly conducted and were not implemented in the context of RCT, and none tested intervention effects on the brain. In this context, our Tools of Dialogue© intervention, built on the conceptual frame of the neurobiology of human attachments and the mechanism of *biobehavioural synchrony*,[1,2] is highly promising.

Seven years after the intervention, we contacted the participants who were by now young adults (24–25 years) that can make a real political impact and engage in civil duties and responsibilities. Our survey included multiple questions on the conflict and these were aggregated into a "peace proactivity" construct that included items such as "I believe peace is possible", "Eventually Jews and Arabs will have to achieve peace" and "I engage in active peacebuilding efforts". We found that the degree to which the neural marker of prejudice attenuated from T1 to T2 predicted the degree to which the young adult considered peace a viable possibility and participated in active peacebuilding efforts. Our findings, therefore, not only show alteration in key functions of the social brain but also emphasise that the brain change carried a long-term impact on young adults, tilting their attitudes towards compromise, hope, and peacebuilding.

In this context, it is important to emphasise that inter-group conflicts are the world's most imminent problem and adolescents' participation in such conflicts has been continuously on the rise; hence, there is an urgent need to devise interventions that can mitigate their deleterious effects on youth. Our findings highlight the utility of a behaviour-based, dialogue-enhancing intervention that builds bottom-up on coordinated action, biobehavioural synchrony, affiliation and familiarisation, and group activity and ritual. We show that such intervention can make a real change in the biology of hatred

and tilt it towards the pole of love, and these findings are unique and very encouraging.

8 | APPLYING THE TOOLS OF DIALOGUE© INTERVENTION TO OTHER CONTEXTS OF INTERGROUP CONFLICT

Inter-group conflict – between races, religions, nations, tribes, or ethnicities – is among the world's most imminent problems and a UNISEF report of 2018[77] has indicated that one in five children globally is growing up in the context of inter-group hatred, active conflict, strife, and danger. Inter-group conflicts lead to horrible atrocities that are often directed towards civilian populations, create immense suffering, and may perpetuate for decades so that generation after generation are born into a bleeding conflict. The Israeli-Palestinian conflict is an example of such highly intractable intergroup conflict that has led to over a century of immense suffering, deep hatred, marked prejudice, and inability to make actual steps towards compromise and peace.[78] From a young age, children of both groups are socialised to distrust the other group, form negative attributions, exhibit minimal empathy, and derogate and dehumanise the other who is believed to be the enemy.[49,79] These, in turn, trigger intense fears that further limit the opportunities for dialogue among the two groups, despite the fact that dialogue is the only way to move out of this long-lasting deadlock.[80]

The Tools of Dialogue© intervention attempts to chart one way out of this deadlock and is, in fact, the first intervention that has shown a broadband effect on brain, behaviour, cognition, and biology and a long-term impact. Nearly 70 years ago, in the aftermath of World War II, Allport (1954)[43] introduced the "contact approach" and suggested that personal contact is a "must" in the context of intergroup conflict. Still, hundreds of interventions that adopted the contact approach yielded mixed results and none reported long-term outcome.[44] While our intervention is built on the face-to-face component proposed by the "contact approach", it added insights from our *biobehavioural synchrony*[2,5,33] frame and from our conceptual model on the double-edged nature of the biology of love and hatred.[3] Coordinated actions, synchronised movement, cultural rituals, holy scriptures, and familiarisation with the other's affiliation matrix were used as the background upon which we began discussions on key topics of dialogue. In these discussions, we focused on the behavioural, active components of the topic, not on its philosophical, political, historical, or social aspects, charting a novel, bottom-up, behaviour-based approach to conflict resolution. Our approach differs from most intergroup interventions that are built on explanation, social cognitions, cognitive biases, or the perception of "justice". We allow our participants to "do things" together, move and play "in tandem", and discover a set of behaviours that can be useful for peace-building rather than altering cognitions or argue who is more "right", whose suffering is greater, or who can assume the role of the victim. Our long-term research on mother–infant synchrony as the basis for complex social abilities, such as empathy, perspective-taking, and mutual respect,[2,47] determined our approach to focus efforts on synchrony and allow complex cognitions to flexibly emerge upon it.

We believe that the Tools of Dialogue© intervention can be adapted to other societies, languages, settings, and areas of conflict. First, the age of the participants can be expanded with some modifications of the specific tasks. Since the intervention relies on children's ability to contemplate multiple perspectives and engage in abstract discussions, it is not recommended to use the intervention before the age of 14 and some adaptations would be required for the 14- and16-year range. We similarly envision adaptation of the intervention to a school setting, which may require briefer sessions than the 2.5–3 h sessions conducted here and some changes are required for a school-based setting. Other contexts that can benefit from the intervention are colleges or university settings, large firms, or social organisations (e.g., army, police) in which members of several groups, such as different races or nationalities, need to work in collaboration on a daily basis. The Tools of Dialogue© intervention can be adapted to older ages: young adults or adults and the specific tasks or texts need to be adapted to various ages, languages, and cultural heritage.

Adaptation of the intervention can target inter-racial contexts of individuals born in the same country that speak the same language but carry long-term issues related to prejudice, inequality, resentment, and fear towards outgroup members; notable examples in this category are blacks and Whites in the US or Native Americans in the US or Canada. Other inter-group relations may be among individuals who hold very different and even opposing world views, those who consider the other side not only as different but as dangerous, hostile, and even toxic to the in-group's survival; for example, Ultra-Orthodox versus secular citizens in Israel or in other countries where religion has strong historical roots but the country also contains a strong secular/academic class, such as Turkey, Lebanon, or Italy. The intervention may also be relevant to right- and left-wing-leaning groups, with the goal of allowing individuals to hold political opinions without the accompanying hate and prejudice of the other, a condition that is destroying many democratic societies.

Finally, the intervention may be applied to those whose mother's tongue is different from the majority of their fellow citizens, those who come not only from a different background but from a foreign country. This can include immigrants that have fled to countries that offer a better life in Europe or North America and the dialogue between the two groups has a strong imbalance of power and contains elements of fear and, at times, dehumanisation of the immigrant. Ultimately, the intervention can be beneficial to societies that have been in active war against each other but share a border or have a dispute over the same land (e.g., Israel, South Africa, Ukraine, or Cyprus). In such contexts, it is possible that people-to-people initiatives, using instruments such as the Tools of Dialogue©, may bring about change from the bottom up through personal encounters, familiarity, and empathy, despite obstacles placed by governments and political and religious leaders.

In sum, love and hatred – humans' most fundamental emotions – are supported by ancient systems that are entrenched, difficult

to change, and based on social behaviour. Applying the mechanisms of synchrony, familiarity, and coordination in the context of an evidenced-based intervention may tilt the biology of hatred, prejudice, and ethnocentricity towards the pole of love, empathy, and dialogue. While interventions are costly and effortful, their impact on the general public is slow and checkered, and the immense endeavor may at time feel futile, the other option is indifference, helplessness, and despair. We must remember that despair is not an option; we are obligated to our children to find the best options science can offer to make a better world for a future of co-existence, tolerance, and respect.

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CONFLICT OF INTEREST STATEMENT

The author declares no conflict of interest.

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