Understanding the psychological contract: an intricate mind-game.

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Abstract
This academic paper explores the influence of psychological contract breaches on trust and distrust in the context of buyer-supplier relations. Within this paper trust and distrust are viewed as separate constructs and measured independently through neuroscientific methods. Both the application of neuroscience and good practices are briefly touched upon. The EEG signals of six participants were documented during a buyer-supplier simulation game which encapsulated the fundamentals of both trust and distrust. The observations were promising because the direction of effects was consistent with expectations based on previous neuroscientific frontal asymmetry literature. Further research is needed to examine statistical significance of the hypothesized effects.

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1 INTRODUCTION

Typically, buyer-supplier relations are managed with the aid of written contracts. However, not all variables can be incorporated or foreseen. Especially complex environments with high monitoring and structuring costs build on alternative governance mechanisms (Lumineau & Malhotra, 2011; Malhotra & Murnighan, 2002). Even if there are written contracts in place, a significant amount of the relationship may be built on psychological contracts between individuals (Rousseau, 1989). A psychological contract is an implied obligation of reciprocity within relationships and is defined as: “an individual's beliefs regarding the terms and conditions of a reciprocal exchange agreement between that focal person and another party” (Rousseau, 1989, p. 123).

In the complex environments where written contracts are unable to cover all aspects of the relationship a greater emphasis is placed on trust. Lewicki et al. defined trust as: *“confident positive expectations regarding another's conduct”* (1998, p. 439). The definition of trust implies a willingness to be vulnerable towards another party based on expected rewards. Because of its central role in complex environments and its several relational benefits it is interesting to examine how trust relates to psychological contracts (Jiang et al., 2011; Johnston et al., 2004; Shapiro et al., 1992).

Similarly to trust, distrust can affect and be affected by psychological contracts (Rani et al., 2018; Searle & Ball, 2004). Traditionally distrust is considered to be on the other end of the same spectrum as trust (e.g., Rotter, 1967). However, the trust theory considers distrust as a separate construct from trust and defines it as: *"confident negative expectations regarding another's conduct*" (Lewicki et al., 1998, p. 439). Which implies an unwillingness to be vulnerable towards another. These definitions of trust and distrust suggest that distrust is not on the same spectrum as trust because rather than an absence of trust, distrust entails actively negative predictions (Cho, 2006; Lewicki et al., 1998). This study builds on the trust theory and thus recognises the separation of trust and distrust. Viewing the relationship between distrust and psychological contracts separately from trust is interesting because distrust provides its own benefits (unrelated to trust) in business-to-business environments (Kramer, 2002; Lewicki et al., 1998).

While the topic of trust enjoys a large body of literature, research on distrust lacks behind (Guo et al., 2017). This discrepancy is caused due to the challenge of identifying the two concepts separately with traditional behavioural research methods (Dimoka, 2010). One of these challenges stems from the social desirability biases to which behavioural research methods are susceptible. Social desirability biases arise when participants aim to underreport undesirable or negative behaviour and feelings. This applies to research concerned with trust and distrust because distrust is generally considered as negative and detrimental (Guo et al., 2017). Cognitive neuroscience, the study of neurophysiological processes in the human brain, may provide a solution to the requirement to identify trust and distrust separately (Dimoka, 2010; Krueger et al., 2007; Oh et al., 2022; Wang et al., 2018). New ways of observing trust and distrust as separate constructs are needed, such as measuring correlated brain activity, unbothered by social desirability biases. Understanding interpersonal dynamics like trust and distrust in business-to-business relationships is essential to improve buyer-supplier collaborations (Andersen & Kumar, 2006; Tähtinen & Blois, 2011). However, there is currently no study present that examines these constructs as distinct with separate cognitive processes and separate effects on managerial behaviour. To address this gap in the literature this study aims to address the following research question:

How do (different types of) psychological contract breaches influence the trust and distrust of the buyer?

To answer this research question, this study takes a new approach, which has rarely been applied in SCM (supply chain management) studies. Specifically, electroencephalogram (EEG) data was gathered during a buyer-supplier simulation in which participants assumed the role of the buyer. The goal of the buyer-supplier simulation was to replicate a reciprocal psychological contract in which the participant choses to be vulnerable, which represents a baseline of trust (Dimoka, 2010). The willingness to be or not to be vulnerable was used because it represents a rudimental difference between trust and distrust (Krueger & Meyer-Lindenberg, 2019). After a trust baseline was established two types of psychological contract breaches with varying intentionality, i.e., incongruence and reneging, were mimicked. Following the breach, the impact on the power of theta and alpha oscillations over the frontal lobe was measured. Special emphasis was on changes in frontal asymmetry.

The expected impacts on cortical (measured as inverse alpha) and theta activity were based on previous asymmetry literature (e.g., Gable & Dreisbach, 2021; Harmon-Jones & Gable, 2018; Vecchiato et al., 2014). Due to previously established correlations, higher relative right frontal cortical activity was used as a measure of distrust and higher left frontal cortical activity was used as a measure for trust. The power of the oscillations per region was assessed by performing wavelet analyses (Herrmann et al., 2005). The employed statistical approach was based on the collapsed localizer technique (Luck & Gaspelin, 2017).

Although more research is needed to solidify the connection between the neural correlates and mental processes of both trust and distrust, the direction of effects indicates a decrease in trust and increase of distrust after a psychological contract breach. Furthermore, this study contributes to SCM literature by emphasizing the relevance of intentionality in buyer-supplier relationships. While the study aimed to measure trust and distrust separately it does not *prove* that trust and distrust are distinct concepts, this is only derived from theories in previous literature. However, this study highlights the challenges to confirming (and adds to the ongoing discussion on) the separation of the concepts. In doing so, it extends a more nuanced platform on which classic supply chain management theories can be applied.

The following sections are structured as follows: the theoretical frameworks on which the study is build are touched upon, the relevant concepts are defined and described based on previous literature, the hypotheses are formulated, the applicability of cognitive neuroscience is considered, the methodology of this study is shown, and finally the results are presented and discussed.

2 LITERATURE

2.1 The trust theory as a theoretical framework

Trust has been researched in a wide range of academic literature, such as philosophy, medicine, and computer science (Artz & Gil, 2007; Blois, 1999; Fritz & Holton, 2019; Hieronymi, 2008). Additionally, trust has been extensively discussed in business-to-business contexts due to its necessary role in obtaining an effective buyer-supplier relationship (Doney & Cannon, 1997).

Within buyer-supplier relationships, trust concerns the confidence that the exchange party is capable to fulfil its commitments, possesses the drive to pursue outcomes that benefit everyone involved and will not misuse the partnership (McKnight & Chervany, 2001a; Morgan & Hunt, 1994). In contrast, distrust is viewed as the conviction that a partner lacks competence, is irresponsible and actively tries to inflict harm (Lewicki et al., 1998; Sitkin & Roth, 1993). These descriptions seem to denote that trust and distrust are two ends of the same spectrum, as conceptualized in traditional trust research (e.g., Rotter, 1967). In other words, traditional trust research viewed trust and distrust as one variable with complete trust as one extreme and complete distrust as the opposite extreme. However, this study is built on the modern view of the constructs, provided in the trust theory. The trust theory views trust and distrust as separate, with trust comprised of actively positive expectations and distrust formed by actively negative expectations (Lewicki et al., 1998; see Table 1).

Rousseau et al. (1998, p. 399) argued that "belief in the absence of 'negative intentions' is not the same as belief in the presence of positive intentions—the latter being a necessary condition of the generally accepted definition of trust." In agreement with this argument, Lewicki et al. (1998) conceptualized trust and distrust as separate. This is critical because

Table 1

Definitions, foundations and consequences of trust and distrust identified in previous literature.

Authors	Trust	Distrust
	Definitions	
Sitkin and Roth (1993)	"belief in a person's competence to perform a specific task"	"the belief that a person's values or motives will lead them to approach all situations in an unacceptable way."
Lewicki et al. (1998)	"confident positive expectations regarding another's conduct"	"confident negative expectations regarding another's conduct"
Rousseau et al. (1998)	"a psychological state comprising the intention to accept vulnerability based upon positive expectations of the intentions or behaviour of another"	
	Foundations	
Sitkin and Roth (1993)	Competence Task reliability	Mismatch values and motives
Kramer (1994)		Paranoid thought patterns
Mayer et al. (1995)	Ability, benevolence, integrity, communication, satisfaction, willingness to be vulnerable	
Lewicki and Bunker (1996)	Rational and calculative	
Jarvenpaa et al. (1998)	Ability, benevolence, integrity	
Lewicki et al. (1998)	Hope, faith, confidence, assurance, initiative	Fear, scepticism, cynicism, wariness, vigilance

Kramer (1999)		dispositional and situational factors that influence individuals' self-consciousness, stress, diverse challenges
Kramer (2001)		Irrational, more emotional
McKnight and Chervany (2001a)	Calm, security	Fear, worry
McKnight and Chervany (2001b)	Low intensity emotions	High intensity emotions
McKnight et al. (2004)		Fear, doubt, worry, panic, paranoia, and anger
Carey et al. (2011)	Exchange reciprocity	
Poon (2013)	Ability, benevolence, integrity	
Franklin and Marshall (2019)	Competence, satisfaction, communication, integrity, shared values, benevolence, co-creation	
	Consequences	
Slovic (1993)		Privilege negative evidence over positive evidence
Brenkert (1998)	Sensitive information sharing	
Lewicki et al. 1998	Initiative, relationship development, frequent interactions	More efficient group functioning, significant monitoring, guarded conversations, economic order.
Kramer (1999)		Psychological barriers to trust, relatively active mindful processing of attribution relevant information
Kramer (2001)		Less rational responses
Walgenbach (2001)		An increase in control in interorganizational relationships
Kramer (2002)		Information investigation, alertness
McEvily et al. (2003)	Possible abuse of misplaced trust or a surfeit of trust, systematic biases	
Doney et al. (2007)	High customer retention, commitment, obtaining high percentage of buyer's purchases	
Molina-Morales et al. (2011)	Lower monitoring and transactions costs	
Oomsels and Bouckaert (2014)	Increased cooperation, flexibility, innovation, learning, goal-orientation, performance, pro-social behaviour, cost-efficiency, blindness to failure and vulnerability to opportunism	Atomization, regulation, behavioural control, high opportunity costs and predictable transaction costs
McKnight et al. (2017)	Calmness, obtain a high percentage of buyer's purchases	Complexity

failing to research distrust as a distinct concept generates a simplified perspective of the constructs with a biased estimate of the effect of trust (Eckerd et al., 2016; Truong, 2019). This section aims to provide clarity on the division of trust and distrust based on the arguments provided by the trust theory.

The trust theory draws on the difference in emotional states attached to both constructs (see Table 1). High trust is built on hope, faith, assurance, initiative, calmness and security (Cho, 2006; Lewicki et al., 1998; McKnight & Chervany, 2001a). Consequently, low trust is most accurately described as a lack of these emotions. In contrast, high distrust is comprised of fear, suspicion, cynicism and worry (Cho, 2006; Lewicki et al., 1998). Not only are the emotions linked to low trust and high distrust different, the latter also operate at a higher intensity level (McKnight & Chervany, 2001b). Additionally, the difference between these emotional states causes trust to operate at a rational and calculative level opposed to distrust which is associated with paranoid thought patterns and irrational emotional responses (Kramer, 1994, 2001; Lewicki and Bunker as cited in Searle & Ball, 2004). Lewicki et al. (1998) argued that because low trust and high distrust are not the same, trust and distrust cannot be on the same continuum and are thus different constructs.

In a study on business-to-consumer internet exchanges Cho (2006) tests the judgement dimensions forming trust and distrust, *benevolence* and *competence*. Benevolence is referred to as the amount of genuine interest in another's welfare and competence describes a partner's capability and reliability. Cho (2006) found that while trust- and distrust-building are based on the same judgement dimensions, the favourable impacts on trust building are not the same as the unfavourable impacts on creating distrust, and vice versa. Put differently, benevolence is deemed to primarily stimulate trust and competence mostly decreases distrust. This difference in the weight between the judgement dimensions of trust and distrust is in line with the separation of the constructs (Guo et al., 2017; Lewicki et al., 1998) and even incorporated in some definitions of the constructs (Sitkin & Roth, 1993).

Lewicki et al. (1998) also theorized that if trust and distrust indeed are separate constructs, there should be some difference in their relationship with other variables resulting in different consequences (see Table 1). Sitkin and Roth (1993) already conducted an empirical study which demonstrated that trust and distrust function in distinct ways with contrasting outcomes. Since then various other studies have highlighted the differences in outcomes of trust and distrust, such as differences in cost-efficiency, atomization, monitoring, opportunity costs, innovation, complexity and the intention to use online banking systems (e.g., Benamati et al., 2010; McKnight et al., 2017; Oomsels & Bouckaert, 2014).

2.2 Trust and distrust and their relation to vulnerability

While both trust and distrust can aid decision-makers in social interactions, they each do so in distinct ways (Cho, 2006). Trust mitigates undesirable conduct from consideration by establishing the desirable conduct as a certainty, a simplified yet vulnerable position to take (Cho, 2006; Guo et al., 2017; Henseler, 2018). In contrast, distrust leads to higher complexity due to higher monitoring, and lower willingness to be in a position of vulnerability (Dimoka, 2010; Guo et al., 2017; McKnight et al., 2017). Consequently, testing whether or not someone is willing to accept a vulnerable position separates the trust and distrust based on a fundamental element of both constructs (Krueger & Meyer-Lindenberg, 2019). This has become a common technique to measure trust and distrust in relationships (e.g., Agarwal & Narayana, 2020; Cho, 2006; Krueger et al., 2007; Wang et al., 2018).

2.3 Trust and distrust separated as cognitive processes

Cognitive neuroscience is the study of the neurophysiological processes related to behaviour and thought in the human brain. The two most popular neuroscientific methods fMRI and EEG (Lim, 2018a) have both offered new perspectives on the separation of trust and distrust (see Table 2). EEG measures electrical activity in the brain, these complex signals are then separated into oscillations with different frequencies. A typical wavelength division is theta (4 – 8 Hz), alpha (8 – 13 Hz), beta (13 – 30 Hz) and gamma (30 – 80 Hz; e.g., Fingelkurts et al., 2007; Herrmann et al., 2005; Miller, 2007). An EEG study by Oh et al. (2022) assessed brain activity in alpha, beta, and gamma oscillations of 18 individuals (9 female, 9 male) during a slideshow that showed various words linked to trust and distrust. They found higher alpha and beta activity in the frontal lobes during the display of words linked to trust and higher gamma activity in the temporal lobes when words linked to distrust were displayed (Oh et al., 2022). Consequently, Oh et al. (2022) presented the frontal lobe and temporal lobes as neural correlates for trust and distrust, respectively. However, they failed to consider important factors such as the timeframe of measurements and potential confounding variables related to reading such as word frequency, predictability and word length (Kretzschmar et al., 2015 Schuster et al., 2016). For example, word frequency also influences the activity in the temporal lobe (Schuster et al., 2016). Furthermore, EEG seems not the most accurate method to measure gamma waves. Moreover, Oh et al. (2022) assumed that the superficial brain activity measured in their study aligns with findings of other studies that incorporate analysis of deeper brain structures such as the fMRI study by Dimoka (2010). fMRI studies analyse blood oxygen levels and have better spatial resolution than EEG studies (Alvino et al., 2020). Dimoka (2010) also found distinct spatial dimensions correlated to trust and distrust based on fMRI data. In other words, their study's identification of distinct neural correlates suggests that trust and distrust may rely on different cerebral regions. Moreover Dimoka (2010) argued that if trust and distrust rely on distinct cerebral regions, they should be regarded as separate constructs rather than ends on a single spectrum, from a cognitive neuroscience standpoint. Some earlier results of EEG and fMRI studies on the neural correlates of trust and distrust and their interpretations are provided in Table 2.

Table 2

Brain regions in which activity is correlated with trust and distrust, based on previous EEG and fMRI studies.

Authors	Trust	Distrust
Krueger et al. (2007)	Paracingulate cortex	
Dimoka (2010)	Paracingulate cortex and caudate nucleus	Insular cortex and amygdala
Wang et al. (2018)	Frontal lobe and occipital lobe	
Oh et al. (2022)	Frontal lobe	Temporal lobe

2.4 Frontal asymmetry literature stresses the separation of trust and distrust and enables measurement of both constructs

Examining the activity related to the more fundamental biological properties that trust and distrust are built on may provide additional insights on the separation of the two constructs. Moreover, Barrett and Wagner (2006) argued that measurement of the fundamental properties of emotions such as their valence and motivational direction is the best way to study the brain's reaction to emotional stimuli. Motivational direction indicates the urge to approach or withdraw from a stimulus (Gable & Dreisbach, 2021; Gable et al., 2018). Motivational direction is evident even in basic organisms, where responding appropriately to positive stimuli (e.g., seeking opportunities for mating or food) and negative stimuli (e.g., evading predators) can be crucial for survival (Kelley et al., 2017). Affective valence entails whether an affect is positive (e.g., happiness, hope) or negative (e.g., anger, fear) based on the subjective feeling surrounding the emotion (Harmon-Jones & Gable, 2018).

Trust can be linked to positive valence based on the valence of the emotions attached to trust, e.g. faith, confidence and satisfaction (Lewicki et al., 1998; Mayer et al., 1995). Additionally, trust is linked to initiative, which highlights the connection to approach motivation (Lewicki et al., 1998). Distrust and negative valence are linked based on the emotions associated with distrust, e.g., paranoia and cynicism (Lewicki et al., 1998; McKnight et al., 2004). The emotions linked to distrust provide an ambiguous position on the motivational direction of the construct. Most of the emotions associated with distrust (e.g., fear and worry) are related to withdrawal (Carver & White, 1994; Sutton & Davidson, 1997). However, anger is considered approach behaviour (e.g., Harmon-Jones et al., 2011; Kemp & Guastella, 2011). Regardless of the ambiguity caused by anger, distrust is generally associated with negative valence and withdrawal (Ng & Ang, 2021).

In cognitive neuroscience literature on motivational direction and valence, findings are generally expressed in terms of 'cortical activity' (Harmon-Jones & Gable, 2018). Alpha activity is assumed to have an inverse relationship with cortical activity, because alpha activity increases during mind wandering and relaxation, especially while the eyes are closed (Barry et al., 2007), and decreases with increasing task demands (Fink et al., 2005). Additionally, various studies combined EEG and fMRI and found negative correlations between resting state alpha activity and blood-oxygen-level-dependent signals measured with fMRI (e.g., Ritter et al., 2009; Yuan et al., 2010). Based on such inverse correlations, alpha activity it is often used as an indicator for cortical activity in literature on motivational direction and valence (e.g., Allen et al., 2004; Harmon-Jones et al., 2022). This study builds on that literature and thus for the remainder of this study a reduction of alpha activity is interpreted as increased cortical activity.

Positive valence and approach are related with cortical activation in the frontal region (see Figure 1) of the left hemisphere whereas negative valence and withdrawal are associated with cortical activation in the right hemisphere (Ekman & Davidson, 1993; Gainotti, 1972; Poole & Gable, 2014; Schaffer et al., 1983; Schöne et al., 2016). Because trust has been associated with positive valence and approach direction, an increase in frontal cortical activity (so reduced alpha power) in the left hemisphere may indicate higher levels of trust (Davidson, 1992; Harmon-Jones et al., 2022; Vecchiato et al., 2014). Similarly, based on the connection between distrust and withdrawal and negative valence, an increase of frontal cortical activity (so a reduction of alpha power) in the right hemisphere may indicate an increase of distrust.

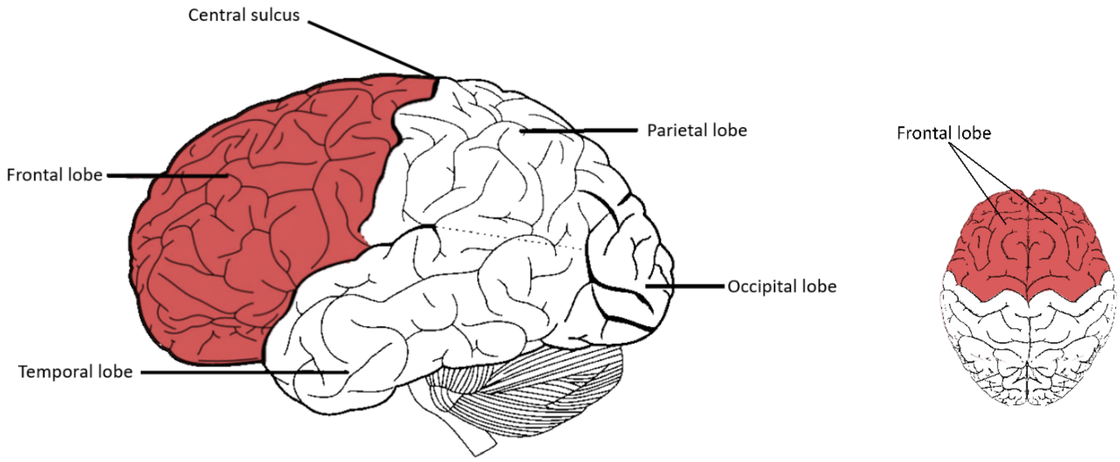


Figure 1. Side and top view of the brain, highlighting the various regions of the cerebral cortex.

Thus, by measuring neural activity from both the left and right frontal regions researchers may make inferences about trust and distrust levels in the brain. Additionally, investigating the balance between the left and right frontal region may convey whether trust or distrust is more dominant, which is a common approach in the frontal asymmetry literature (e.g., Gable & Dreisbach, 2021; Harmon-Jones & Gable, 2018; Poole & Gable, 2014).

Finally, aside from the extended amount of literature discussing frontal cortical asymmetry based on the lateralized alpha power, Vecchiato et al. (2014) suggested another asymmetry correlation that may distinguish trust from distrust. Namely, they observed higher theta power in the right central region (around the central sulcus) during displays of trust. While such findings are promising, this is currently the only study that mentioned this correlation. The central region is more often correlated with pain (e.g., Chen & Rappelsberger, 1994; Feng et al., 2021). Additionally it is located right above the primary motor cortex, which means some of the measured activity may be a result of movement. With that in mind, additional EEG studies are needed to assess the correlation proposed by Vecchiato et al. (2014).

2.5 The psychological contract

Despite the growing literature, more research is needed to understand the differential relationships trust and distrust have to their antecedents (McKnight et al., 2017). The psychological contract is often researched in conjunction with trust and distrust and may constitute an antecedent to both constructs (the expected relationships are discussed in more detail in chapter 3). A psychological contract refers to an undocumented expectation of mutual reciprocity within relationships. Defined by Rousseau as: “an individual's beliefs regarding the terms and conditions of a reciprocal exchange agreement between that focal person and another party” (1989, p. 123). Psychological aspects impact organizational outcomes and have therefore been of growing interest (Grimmer & Oddy, 2007). The literature has begun to examine psychological contracts on an interpersonal level (Grimmer & Oddy, 2007;Cullinane & Dundon, 2006; Kiazad et al., 2014; Turnley et al., 2003) and on a buyer-supplier level (Eckerd et al., 2016; Gillani et al., 2021; Hill et al., 2009; Kaufmann et al., 2018). In both of these levels two types of psychological contracts have been identified: relational and transactional, with the former entailing socio-emotional factors and the latter focussing on monetary issues (Grimmer & Oddy, 2007; Robinson et al., 1994). Note that these types are not mutually exclusive. While previous studies have found relations between trust and both relational and transactional psychological contracts, the scope of this study is limited to transactional contracts.

2.6 Psychological contract breach

A psychological contract intrinsically only exists in the mind of the beholder (Rousseau, 1989; Shore & Tetrick, 1994). Consequently, a contract is breached when one party (hereafter referred to as 'perceiver') believes the counterparty (hereafter described as 'breacher') failed to live up to the reciprocal exchange agreement. Thus, a psychological contract breach is independent from whether or not an actual breach occurs (Robinson, 1996). Morrison and Robinson define a psychological contract breach as: "The realization that a party has failed to meet one or more obligations within one's psychological contract in a manner commensurate with one's contributions" (1997, p. 230). In short, a psychological contract breach is a perceived lack of reciprocal exchange. Within this paper the influence of psychological contract breaches on trust and distrust levels is researched.

2.7 Incongruence and reneging as antecedents of psychological contract breach

Psychological contract breaches can be categorized based on the causes or thought patterns forming them. Extant literature has established two root causes of psychological contract breaches: reneging and incongruence (Robinson & Morrison, 2000; Thompson & Bunderson, 2003; Grimmer & Oddy, 2007). Reneging occurs when the breacher acknowledges that an obligation is in place but purposefully neglects it. In contrast, incongruence is caused by a difference in understanding of the breacher's obligations to the perceiver. In other words, the difference between these two antecedents is the intentionality of the breacher.

3 HYPOTHESES

This chapter provides the argumentation why cause and effect relationships are expected between different psychological contract breaches and trust and distrust. First the hypothesised link between psychological contract breach and trust and distrust is addressed, afterwards the different impacts based on incongruence and reneging are considered.

3.1 The linkages between psychological contract breach and trust and distrust

Extant literature suggests that based on the exchange reciprocity on which psychological contracts are built, unbreached psychological contracts increase trust over time whereas psychological contract breaches decrease trust. For example, Molm et al. (2009) argued that because there is risk involved in relationships, exchange reciprocity over time strengthens the belief that the exchange partner will not manipulate or take advantage of an actor in the future, which fosters trust. Additionally, if the perceiver perceives a lack of exchange reciprocity a dissonance between their trusting beliefs and reality arises and they are led to revise their trusting beliefs to provide consistency between their beliefs and reality (Chou, 2012; Festinger, 1962). The extent to which perceivers revise their trusting beliefs is dependent on the amount of dissonance created (Harmon-Jones & Mills, 2019). Scheer et al. (2003) provided empirical data indicating that the revision of trusting beliefs caused by a lack of exchange reciprocity constitutes a decrease in trust. Additionally, while trust was not reviewed as a separate construct from distrust in their study, Eckerd et al. (2016) found empirical evidence indicating a decrease in trust as a consequence of psychological contract breach.

Scheer et al. (2003) also acknowledged the link between unreciprocating behaviour and distrust. Furthermore, a direct link between psychological contract breaches and distrust was suggested by Rani et al. (2018). They made this suggestion based on prior research by Lewicki et al. (1998) and Weiss and Cropanzano (1996). Lewicki et al. (1998) advocated that distrust obtains an affective character and Weiss and Cropanzano (1996) posed that that any positive or negative event is likely to cause affective reactions that have an impact on behaviour. Consequently Rani et al. (2018) proposed that psychological contract breaches could be an antecedent to distrust because a negative previous event, namely a psychological contract breach, is likely to result in negative affect, for example distrust.

Moreover, a the link between psychological contract breaches and distrust is endorsed by the negative emotions surrounding the concepts (Piccoli & De Witte, 2015). A psychological contract breach is interpreted by the perceiver as unfair interpersonal treatment because the perceiver does not feel like the breacher provided an adequate reciprocal response (Morrison & Robinson, 1997; Robinson & Morrison, 2000). Feelings of unfairness and unreciprocating behaviour are customarily linked to negative emotions such as doubt or anger (Harth & Regner, 2017; Lok et al., 2009; Trada & Goyal, 2017), which are foundations of distrust (McKnight et al., 2004). Moreover, a study by Elsbach et al. (2012) on employee trust and distrust demonstrated that perceived unfairness can be a direct antecedent to distrust. Additionally, failures to meet expectations lead to cynicism as an attitude of distrust (Andersson & Bateman, 1997).

In conclusion, a psychological contract breach causes the perceiver to revise their beliefs, which entails a decrease of trust. Furthermore, a negative event like a psychological contract breach may increase an affective state like distrust through the negative emotions on which distrust is built. Based on these statements the following hypotheses were formulated.

H1a *Following a psychological contract breach, trust decreases.*
H1b *Following a psychological contract breach, distrust increases.*

Based on the neurophysiology literature on frontal asymmetry, H1a proposes that the cortical activity in the left side of the frontal region is expected to decrease after a psychological contract breach. H1b implies that after a psychological contract breach right frontal cortical activity increases. Together these two imply a shift towards relative right cortical activity. Additionally, according to H1a the right central asymmetric theta activity is expected to reduce after the breach.

3.2 The varying impacts of incongruence and reneging on distrust

Some previous studies have argued that there are qualitative differences between incongruence and reneging but the outcomes do not differ because the perceiver is unaware of the breacher's intentionality and will perceive them as the same (Morrison & Robinson, 1997; Piccoli & Ives, 2003). Conforming to this view, Piccolo and Ives (2003) demonstrated that trust declines can be caused by actions based on both incongruence and reneging.

However more recent empirical evidence shows that psychological contract breaches based on incongruence and reneging do have different consequences for subsequent order quantities and trust (Eckerd et al., 2016). A plausible explanation could be that the perceiver may uncover the intentionality of the breacher because the perceiver is highly motivated to investigate the antecedents of negative or unexpected events (Wong & Weiner, 1981). Additionally, a psychological contract breach does not implicate that a relationship is immediately terminated, therefore, communication may persist after the breach. Whether or not distrust is affected differently by incongruence in comparison to reneging is still unclear.

Extant literature states that a violation of expectations can lead to a decrease in trust, an increase of distrust or both, dependent on the intentionality of the breacher (Chan, 2009; Grover et al., 2019). Hence, because a psychological contract is a set of expectations between parties, a breach based on incongruence may impact distrust differently compared to a psychological contract breach based on reneging. Zucker (as cited in Oomsels & Bouckaert, 2014) argued that a breach in expectations does not increase distrust if the perceiver believes it to be an isolated event. Tomlinson and Lewicki (2006) expressed similar reasoning to Zucker's statement and maintain that distrust is expected to increase based on the magnitude of its violation, the number of past violations and the perceived intentionality behind those violations. Finally, Guo et al. (2017) posed that distrust is more likely to be influenced by malicious intent.

In sum, psychological contract breaches based on incongruence are less likely to increase distrust in comparison to psychological contract breaches based on reneging, because the latter insinuates a higher probability for reoccurrence of events to the perceiver and is based on malicious intent. To test this discrepancy the following hypothesis was formulated.

H2 *A psychological contract breach based on reneging leads to a more pronounced increase in distrust compared to a psychological contract breach based on incongruence.*

Based on the correlations between asymmetric activity and distrust, H2 implies that the increase in right frontal cortical activity is more pronounced after a psychological contract breach on reneging in comparison to incongruence.

4 COGNITIVE NEUROSCIENCE

This is an interdisciplinary study because the supply chain management related hypotheses are tested with cognitive neuroscience methods. This chapter provides a small overview of what cognitive neuroscience entails, why it is relevant to this study and possible pitfalls for those lacking experience with the field.

4.1 The academic field of neuroscience

The nascent academic field of neuroimaging has already been applied in many fields such as, medicine, psychology, arts, marketing, entrepreneurship and economics (Butler & Senior, 2007; Camerer et al., 2004; Cristofaro et al., 2022; Cucino et al., 2021; Klöppel et al., 2012; Lee et al., 2007; Lubman et al., 2004; Nadal, 2013). Neuroscience has also made its way to business-to-business and buyer-supplier literature (e.g., Aprilianty et al., 2018; Lim, 2018b; Henseler, 2018). This study builds on cognitive neuroscience in a buyer-supplier context. Cognitive neuroscience concerns neuroimaging practices that focus on brain activity related to psychological research (Lizardo et al., 2020).

4.2 Relevance of neuroscience in this study

Brain imaging enjoys a secure reputation as a technique that has and will continue to make important contributions to academic literature (Mather et al., 2013). Proper use of cognitive neuroimaging leads to various advantages. Because aspects of trust and distrust may be captured in specific neurophysiological activity patterns, observing these patterns may provide a more direct insight on the cognitive processes, enabling researchers to bypass intentional decision making biases (Laureiro-Martínez et al., 2015) and participants' inability to articulate thought processes (Massaro et al., 2020).

In this study, intentional decision-making biases are expected as a consequence of social desirability biases. Social desirability biases arise when participants aim to underreport undesirable or negative behaviour and feelings (Grimm, 2010). Social desirability bias is at play because of the differing connotations that trust and distrust enjoy. Trust is considered good, positive and beneficial while distrust is considered bad, negative and detrimental (Guo et al., 2017; Lewicki et al., 1998). However, while these different connotations are apparent, Beccerra and Gupta (1999) noted that while trust can be beneficial, it is not inherently advantageous or disadvantageous. The same could be argued for distrust.

Participants' inability to articulate thought processes limits the extent to which a topic can be researched. Dimoka (2010) showed that by utilizing both behavioural research methods and cognitive neuroscience the distinction between trust and distrust may be more easily detected in comparison to solely using traditional behavioural research methods. Schwitzgebel (2008) stated that next to struggling to find the correct words to describe our emotional experiences, humans have a rather limited understanding of our own feelings.

During an EEG measurement, electrodes are placed on the scalp to measure electrical activity (in microvolts) generated by the brain (Jack et al., 2019). Based on correlations between mental phenomena and the measurable electrical activity, neurophysiologists can reduce the dependency on the vocal descriptions of mental processes provided by participants which is needed in traditional behavioural research. This results in data liberated from social desirability biases, without intervention of a participant's favouritism, through immediate observability with relatively low-cost measurement equipment (Murray & Antonakis, 2019). Moreover, it reduces the reliance on an individual's understanding of the concept and their verbal expression. Additionally, because EEG is relatively portable and provides direct measurement of neural electoral activity, the extent to which EEG findings can be generalized to real-world situations is comparatively high compared to other tools such as fMRI which do not provide such mobility and measure neural activity indirectly (Alvino et al., 2020).

4.3 The application of neuroscience

Cognitive neuroscience has endured some highly sceptical concerns on its implementation in other fields (Jack et al., 2019). Some argued its findings are accepted without critical reflection and its use fails to adhere to methodological standards of established research methods (e.g., Lindebaum & Jordan, 2014). Lindebaum and Jordan (2014) mentioned that there is usually low statistical power and an inability to locate mental phenomena with precision. Moreover, the neural correlates of mental phenomena are just a correlation and thus not the same as the mental phenomenon itself. Ignoring the distinction between the measurable correlates and the interpretation inaccurately implies a higher level of certainty than is actually obtained with cognitive neuroscience methods.

Many pitfalls are the result of assumptions made within cognitive neuroscience and specifically cognitive subtraction. Cognitive subtraction is explained by Jack et al. (2019) as the process of subtracting brain activity associated with a specific task (A) from brain activity associated with a different task (B), followed by the assumption that cognitive processes engaged by task A are linked to the regions that are more active during task A. Three approaches to cognitive neuroscience build on cognitive subtraction: localization of function, forward inference and reverse inference (see Jack et al., 2019 for an extensive explanation). All three approaches are essential but induce challenges to neuroscientific research.

This research can be considered as research that uses reverse inferencing. Reverse inference represents inferences about the nature or functioning of the cognitive processes involved in an activity that are based on the findings of previous neuroscientific localization research. For example, this study builds on the localization of function studies discussed in the literature section on frontal asymmetry (e.g., Harmon-Jones and Gable, 2018). As discussed earlier Harmon-Jones and Gable (2018) linked the cortical activity in the right frontal lobe to withdrawal behaviour, therefore activation of the right frontal lobe may indicate feelings of withdrawal within the participant. However, the right frontal lobe is not *only* linked to withdrawal. Actually, it has been linked to various things. For example, Kang et al. (1991) mentioned a correlation between the right frontal lobe and stimulation of killer cells production. Therefore, activation of the right frontal lobe does not necessarily imply an emotional state of withdrawal within an individual, reverse inference is plagued by this assumption (Poldrack, 2006). Jack et al. (2019) stated that while this hinders the ability of neuroscience to inform psychological theory, reverse inference is inevitable in organizational neuroscience. However, once reverse inference is used the assumptions linked to its application need to be clearly explained and possible other mental processes associated with the hypothesized brain areas relevant to that study should be identified (Jack et al., 2019). Correlations between the relevant regions to this study and other mental processes are listed in appendix Table 1. Similar to any academic field, cognitive neuroscience studies have limitations which are addressed in the discussion section.

5 METHODOLOGY

5.1 Incentives for the application of neuroscience

The key RQ of this study is "*How do (different types of) psychological contract breaches influence trust and distrust of the buyer?"* Therefore, the purpose of this study is to measure differences in trust and distrust after psychological contract breaches. This study builds on the correlation between higher frontal cortical activity in the left hemisphere and the building blocks of trust (Harmon-Jones et al., 2022; Vecchiato et al., 2014). Additionally, a similar connection between distrust and the right hemisphere is used as foundation (Gable & Dreisbach, 2021; Harmon-Jones & Gable, 2018). To test how frontal activity and its asymmetry are influenced, a buyer-supplier relationship was simulated in a game setup. In this simulation the participant has to choose whether or not to be vulnerable, this encapsulates the fundamentals of both trust and distrust as discussed earlier (Krueger & Meyer-Lindenberg, 2019). This 'game' approach has been deployed and shown effective in various previous neuroscientific trust studies (e.g., Krueger et al., 2007; Wang et al., 2018).

5.2 A round in the game

In the implemented approach the participant was assigned the role of a buyer within a buyer-supplier relationship. There were a total of 180 rounds, each round started with a premise: "You made €8 profit, you can choose to invest in your supplier relationship or keep the money." The €8 is a result of routine interactions with the supplier. When the participant chose to keep the money, the €8 was theirs without any risk. If the participant invested the €8 they put themselves in a trusting vulnerable position. If the supplier reinvested there was a €22 payoff for the participant, if their supplier kept the investment the participant was left with nothing. The reaction of the supplier was first displayed through neutral symbols which were explained before the simulation started (see Figure 2). If the simulated supplier did not reciprocate the investment, a message explaining their reasoning was shown. This message

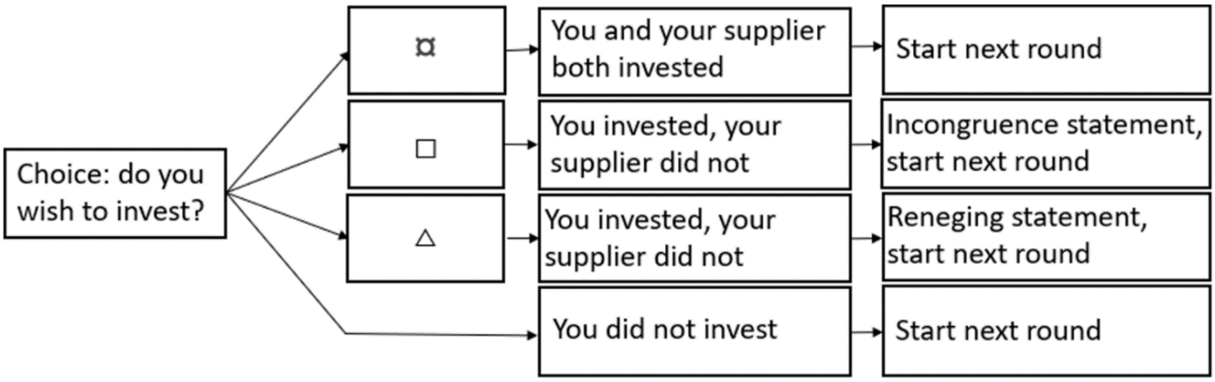


Figure 2. Flowchart of a round in the simulation.

Table 3

Round ending messages after psychological contract breaches.

Displayed message	**Type of psychological contract breach**
Due to lost shipments we were unable to invest in our relationship.	Incongruence
We are still trying to recover financially from missing shipments.	Incongruence
We used the money to invest in better shipment agreements.	Incongruence
Our shipments were blocked by import duties, therefore we were unable to invest this time.	Incongruence
Our supply chain was disrupted, therefore additional investment was not possible.	Incongruence
We had a setback due to new trade laws initialized by our new government.	Incongruence
We invested in one of your tier two suppliers.	Incongruence
We have been investing in innovative products, some of which you may be able to use in the future.	Incongruence
Our company had a merger, which put a hold on other investments.	Incongruence
We did not feel like investing.	Reneging

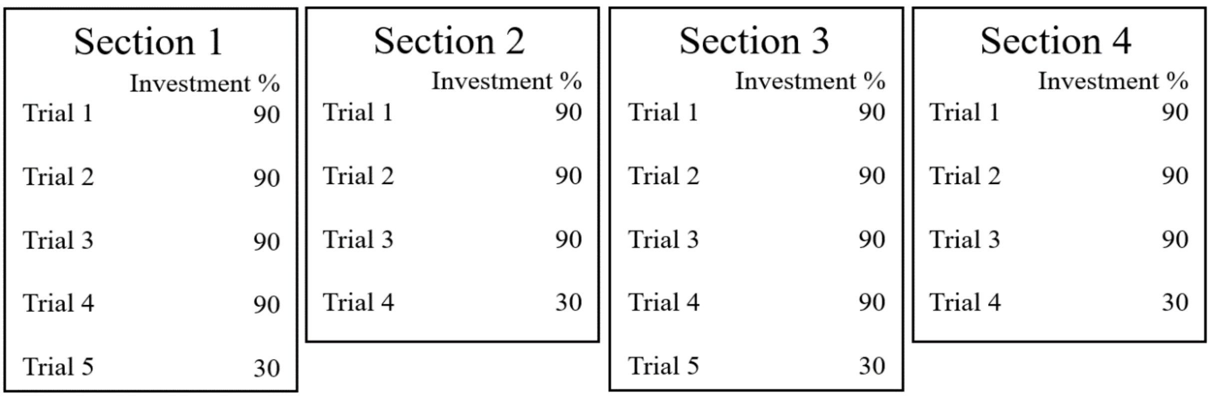


Figure 3. Layout of the game.

was used to remind the participant of the meaning of the symbols by nudging their thoughts towards incongruence or reneging (see Table 3). The incongruence statements indicate that the supplier believes that they do not have to make an investment in certain circumstances, which suggests a difference in understanding of the psychological contract.

5.3 Game development decisions

The total of 180 rounds was divided over trials of 10 rounds. These trials differed in terms of investment reciprocity probabilities (see Figure 3). The trials were grouped in sections, which all started with multiple trials of high reinvestment reciprocity (e.g., section 1, trials 1-4). The number of rounds was needed to establish a trust baseline, this trust baseline represented the successful buyer-supplier relationship prior to any contract breach. Nyaga et al. (2010) stated that longer periods of dedicated investments within buyer-supplier relations have shown to increase trust within both parties. The final trial in each section had a low probability of investment reciprocity (e.g., section 1 trial 5). The low investment reciprocity represented a psychological contract breach. The simulation was programmed such that a 90% probability ensured that exactly nine out of ten rounds would result in reinvestment.

The 180 rounds ensured that every kind of stimulus was observed art least 30 times per participant. This was needed to enable a within-subject design. Charness et al. (2012) mentioned three advantages of within-subject design compared to between-subject design. Firstly, a statistically stronger correlation detection. Which leads to a larger chance of detecting an effect when there is one. Secondly, internal validity does not depend on arbitrary selection, which makes it more likely that the cause-and-effect relationship cannot be explained by other factors. Thirdly, within-subject design is more naturally aligned with most theoretical frameworks. Within this study that translates to a research methodology with higher alignment to how a buyer responds to a specific type of contract breach within a buyer-supplier relationship, not two kinds of buyers in different relationships undergoing different contract breaches. Additionally, utilizing EEG requires a lengthy setup, for which a within-subject design is more befitting.

"Neurobehavioral systems – presentation software" was used to program and run the game during the experiments (*Neurobehavioral systems*, 2023). This program was selected because of the time precision it offers in displaying stimuli (e.g., the symbols conveying the supplier reactions) and the possibility to afterwards analyse highly time specific sections of the EEG data. The code for the game finally consisted of roughly 2400 lines, albeit with some functional repetitions in the code. These lines were written in the two languages of the presentation software: SDL and PCL.

In support of the example set by Wang et al. (2018), the participants received monetary rewards based on their performance in the game. Wang et al. (2018) argued that performance dependent monetary rewards lead to an increased motivation and drive, promoting more engagement during trust games. Additionally, the possibility of losing the money puts the participants in a vulnerable position which provides greater similarity to the real-life social dilemma surrounding trust and distrust within business relationships. Due to the limited budget available, the highest obtainable monetary reward was significantly lower, €10 per participant, in comparison to the study performed by Wang et al. (2018), which was $20.000 per participant.

5.4 Participant selection

In total 10 participants (6 male and 4 female) were scheduled to take part in the experiment. Due to faulty equipment and a no show, ultimately 6 data sets (3 male, 3 female) with clear signals were acquired. Participant selection was based on factors that could influence EEG signals. None of the participants had diagnosed neurobehavioral disorders, an alcohol addiction or electrical devices in their body (e.g., a pacemaker). Furthermore, participants were asked to withhold from alcohol consumption in the last 24 hours prior to the experiment and withhold from caffeine consumption in the last 4 hours prior to the experiment. Participants were instructed on some basic concepts relevant to buyer-supplier interactions before they started the simulation. The ethics committee at the Faculty of Behavioural, Management and Social Sciences at the University of Twente approved the study.

5.5 A 10-20 electrode system subset

Participants' brainwaves were evaluated through a selected subset of the internationally standardized 10-20 system in an actiCap (see Figures 4 and 5). A total of 26 active channels with a sample rate of 1000 Hz were captured as well as a ground electrode in the Fpz position. Moreover, two bipolar electrooculogram (EOG) channels were used to record eye movement. Two EOG electrodes were placed on a vertical line based on the right pupil. The horizontal EOG electrodes were placed level to, but just to the side of both eyes. An additional ground electrode for the EOG was used. This amounts to 32 electrodes for the complete setup.

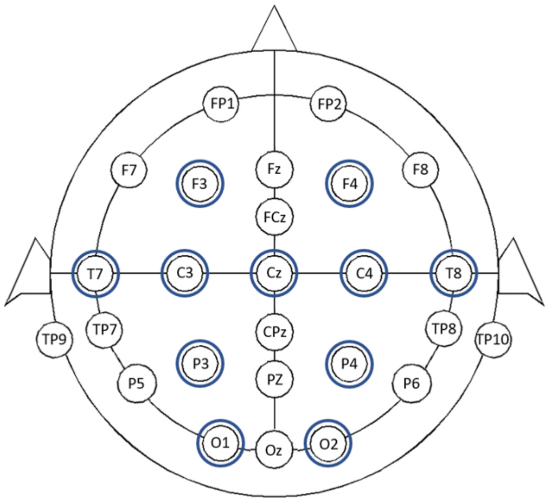


Figure 4. Subset of the 10-20 system.

Within the subset of the 10-20 setup, specific cerebral locations were assigned to different electrode channels, namely the frontal lobe (F3 and F4), temporal lobe (T7 and T8), central lobe (C3 and C4), parietal lobe (P3 and P4) and occipital lobe (O1 and O2). The rest of the electrodes were used to provide a better average reference and more accurate topographies.

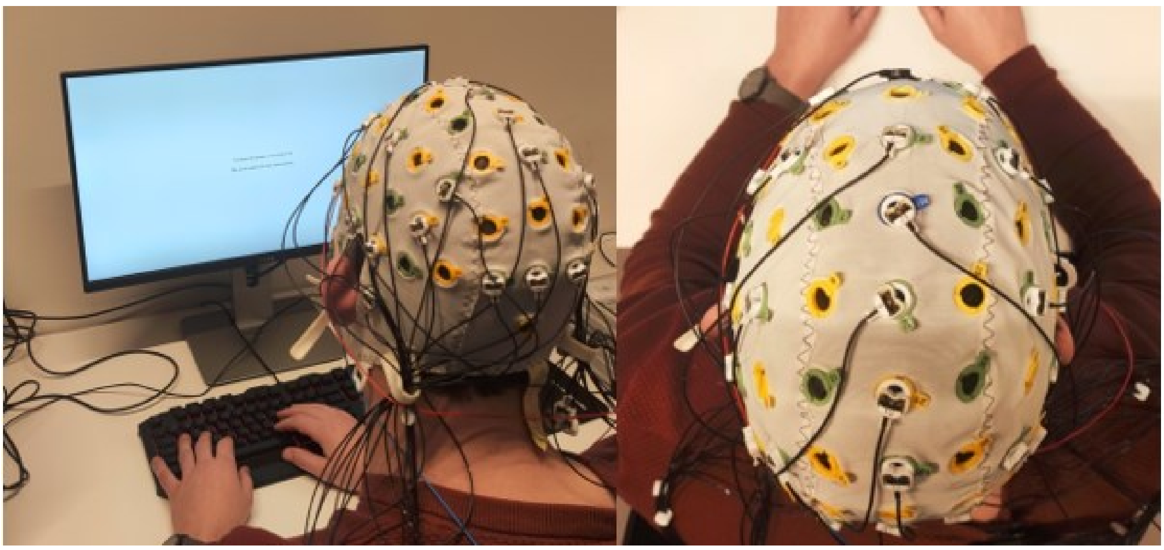


Figure 5. Participant wearing actiCap with connected electrodes.

5.6 The data collection process

Upon entry of the lab participants were handed an informed consent form. Their eyesight was measured for both eyes, their scalp circumference was measured, the position of the Cz electrode determined and a fitting EEG cap was selected. The actiCap was positioned with the location of Cz in mind. The relevant parts of the scalp were thoroughly cleaned with alcohol through the holes of the actiCap and hair was pushed out of the way. Afterwards conductive gel was applied with a dull syringe to provide a direct link to the scalp. The electrodes were attached to the cap and made contact with the conductive gel. The EOG electrodes were added to record the influence of eye-associated artefacts. Finally, the signals of each electrode were subjected to an impedance check and corrected to be below 5 kΩ. Usually the total setup took around 2.5-3.0 hours, the experiment itself around 45 minutes and cleaning an hour per participant.

5.7 The reduction of EEG artefacts

EEG data can be heavily disrupted if the participant blinks, swallows, looks around, focusses their eyes, clenches their jaw or physically moves during the recording. These disturbances are referred to as 'artefacts' within cognitive neuroscience literature and computer programs. Participants were informed on the impact of artefacts and an effort was made to actively prevent them. During the experiment participants were provided with specific moments when they were supposed to blink, swallow, etc. and indicators signalling when artefacts should be suppressed if possible. The latter was achieved by presenting a blank slide with a fixation cross prior to any critical measurement moment. Aside from reducing artefacts, they can be accounted for by specifically recording them and consequently utilizing filters in *BrainVision Analyzer* (an analysis program for EEG data). The EOG electrodes were used with this intention in mind.

5.8 Data filtering and data preparation

The recorded EEG signals were analysed with BrainVision Analyzer 2.2 and checked for clearly distorted electrode channels. No channels were removed during this process as all data was fairly clean. A low cut off filter of 0.1 Hz and high cut off filter of 30 Hz was applied to smooth the EEG signals. Instead of solely using the implied reference electrode (TP9) an averaged reference was created based on all electrodes. Afterwards a raw artefact correction was applied with a low activity cut-off at 0.1µV/ms, a gradient check with 50µV/ms and an amplitude check with minimal -250µV and maximal 250µV allowed amplitudes. These filters are used to remove data that is unlikely to originate from cognitive processes. For example, a 50µV difference in a ms is an unrealistic change in brain activity. Afterwards an ocular correction was applied based on the horizontal and vertical EOG electrodes, using an independent component analysis (ICA). Components assumed to be related to eye movement were removed from the data set, based on the topography, raw signals and regression coefficients. Afterwards the relevant measurement moments for the three conditions (reinvestment, incongruence and reneging) in the dataset were selected, all other segments were removed from the analysis. A baseline correction was applied based on the 200ms prior to the presentation of visual stimuli. Subsequently, a more strenuous amplitude check was applied (-150µV to 150µV).

5.9 Wavelet analysis

Wavelets are models of the signal that are sensitive to oscillations in different frequency bands or sub-bands. In this study the models related to the following frequency (sub-)bands:

theta 4.7 - 6.5 Hz, lower alpha, 6.6 - 9.3 Hz, alpha 9.4 - 13.1 Hz, and beta 13.2 - 18.6 Hz. A wavelet analysis measures whether there is similarity between the raw data and the models and shows the power in a specific frequency band over time (Herrmann et al., 2005). The ability to examine the power of oscillations over time gives wavelet analyses an advantage over Fast Fourier transforms, which impedes the observation of the time course of frequency information (Herrmann et al., 2005).

5.10 Statistical approach

From the cleaned data the relevant time frame and frequencies were identified. Using time intervals from previous studies is questionable because the latency of an effect is dependent on low level sensory variables, for example luminance and distinctness of stimuli (Luck & Gaspelin, 2017). Therefore a collapsed localizer approach was performed on the outcome of wavelet analyses.

The collapsed localizer approach defines the most relevant frequencies and time interval based on an average over all conditions (Luck & Gaspelin, 2017). By averaging the output of the wavelet analyses over all conditions, only 26 wavelet outputs remained, one for each electrode. These 26 wavelet outputs were individually assessed on which frequencies and time intervals were most relevant. Generally the highest activity was recorded in the alpha frequency band (9.4 - 13.1 Hz) during two time frames, i.e., 0-200ms and 500-1500ms. Figure 6 is an average of the 26 wavelet outputs, it provides an overview of the average activity based on all electrodes during the entire experiment and visualizes the findings of the collapsed localizer approach.

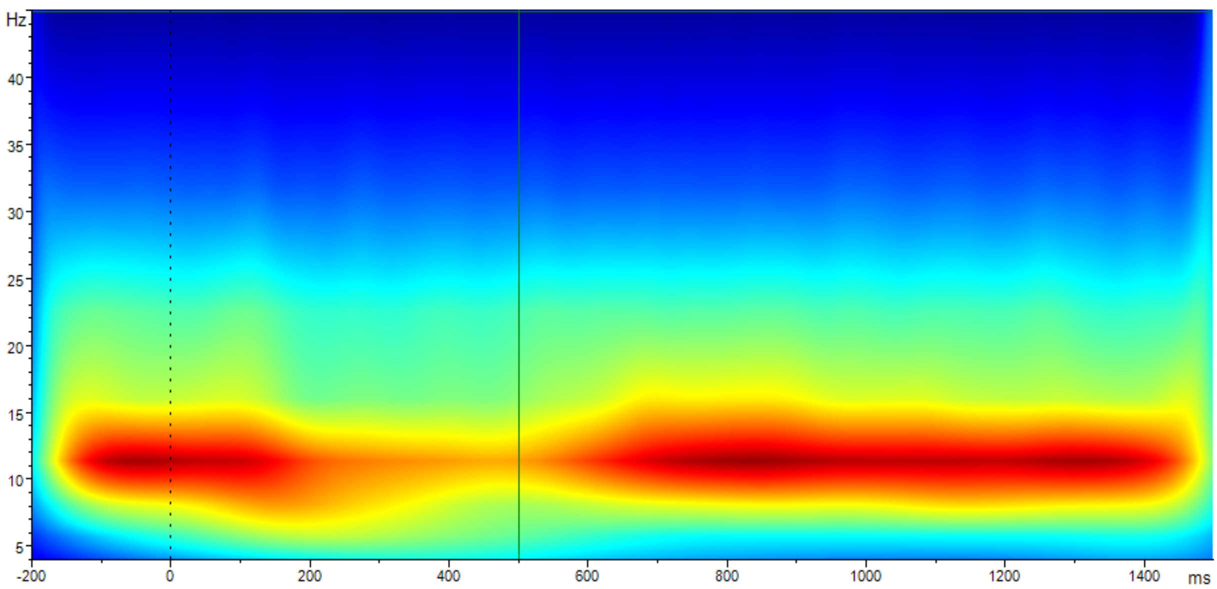


Figure 6. Visualization of the collapsed localizer approach. It represents a grand average of wavelet outputs over participants, conditions and electrodes. The various colours indicate the average power for a certain frequency (y-axis) at a given time (x-axis). Dark red indicates the highest power and dark blue indicates the lowest power. The dotted vertical line at 0ms highlights the moment the symbols were displayed on the screen. The continuous vertical line indicates the start of assumed induced activity.

To understand whether both power surges (0ms-200ms and 500ms-1500ms) are relevant to the study, a distinction needs to be made between evoked and induced activity. While evoked activity is time- and phase-locked to the triggering event (the presentation of a symbol), induced activity is time-locked but not phase-locked (Bastiaansen & Hagoort, 2003). Phase refers to the relative position of an oscillation within a given time period. This distinction is relevant because simply put, in our experiment setup evoked activity is more likely related to anticipation and the visual detection of the symbols on the screen, whereas cognitive processes and perceptions are predominantly manifested in the induced activity (Bastiaansen & Hagoort, 2003; Hosseini et al., 2015).

If activity is not phase-locked it will cancel itself out during an averaging process. Hence, it is possible to isolate or identify evoked brain activity from ongoing EEG signals by averaging the data. Such averages are referred to as ERPs (event-related potentials). By comparing the ERPs and collapsed localizer output it became evident that the first surge (0ms-200ms) was evoked activity because it was also present in the ERPs. This is in line with the visual detection timeframe of the human brain (Amini Vishteh et al., 2019). Because the output within the 500ms-1500ms timeframe was absent in the ERPs, the induced activity and relevant effects to this study were assumed to be located within the 500ms-1500ms timeframe.

After analysing the data in BrainVision analyser 2.2 the data was exported to Rstudio 2022.12.0 (*Rstudio desktop*, 2022). In Rstudio the data was reorganised and graphs were made to visualize the results. Furthermore, the code was written to calculate the frontal asymmetry values. Frontal asymmetry values were calculated by subtracting the natural log values of left sided electrodes from the natural log values of right sided electrodes, i.e., ln(F4) minus ln(F3) (Vincent et al., 2021). This results in negative asymmetry values when cortical activity in the right hemisphere is dominant (the hemispheres are flipped due to the inverse relationship between alpha and cortical activity). Moreover, repeated robust ANOVAs were conducted in Rstudio to examine if there were significant differences in the activity of individual electrodes before and after psychological contract breaches. Finally, robust repeated robust ANOVAs examined if the frontal asymmetry was substantially different after a psychological contract breach.

6 RESULTS

This section purely discusses the results of the study, in the discussion section the possible implications of the data are reviewed with the previously formulated hypotheses in mind.

6.1 Individual electrode analysis

The data was split based on the three conditions (reinvestment, incongruence and reneging). The theta activity for C4 (central region in the right hemisphere) is displayed in Figure 7A. The alpha activity for the frontal electrodes, i.e. electrodes F3 and F4, is shown in Figure 7B. The sample mean theta activity in C4 during reinvestment was found at 2.97μV^2, 95% CI [1.07, 4.87]. After a psychological contract breach based on reneging, the theta activity in C4 dropped to 2.87μV^2, 95% CI [0.90, 4.85]. Psychological contract breaches based on reneging reduced the theta activity in C4 to 2.43μV^2, 95% CI [0.93, 3.93]. Robust repeated measures ANOVA showed that the differences in theta activity are statistically insignificant (Table 4).

During reinvestment F3 and F4 measured the highest power at 8.40μV^2, 95% CI [2.52, 14.3] and 8.24μV^2, 95% CI [2.40, 14.1], respectively. The alpha activity in both the left and right hemisphere decreased after the psychological contract breaches. During after a breach based on incongruence the alpha activity in F3 was reduced to 7.10μV^2, 95% CI [0.55, 13.7] and in

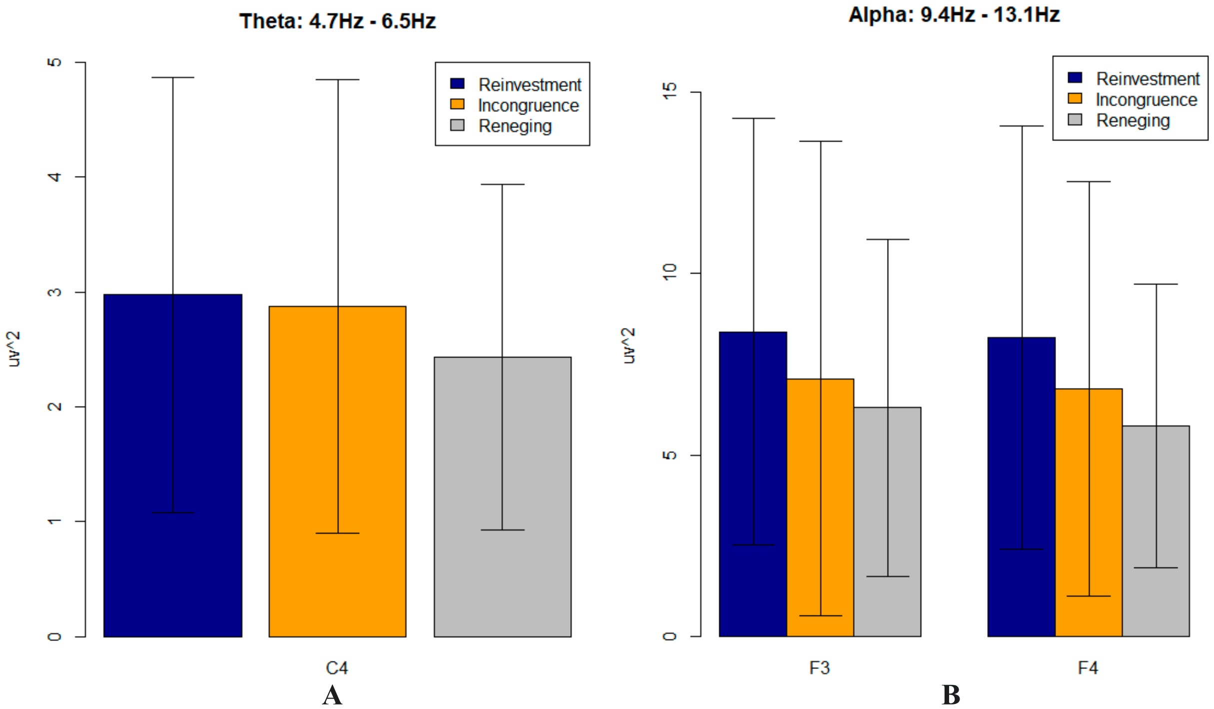


Figure 7. Average induced theta power in C4 (left, A) and induced alpha power in F3 and F4 (right, B) after the presentation of the three conditions (reinvestment, incongruence and reneging) expressed in μV². The vertical bars indicate their respective 95% confidence intervals.

Table 4

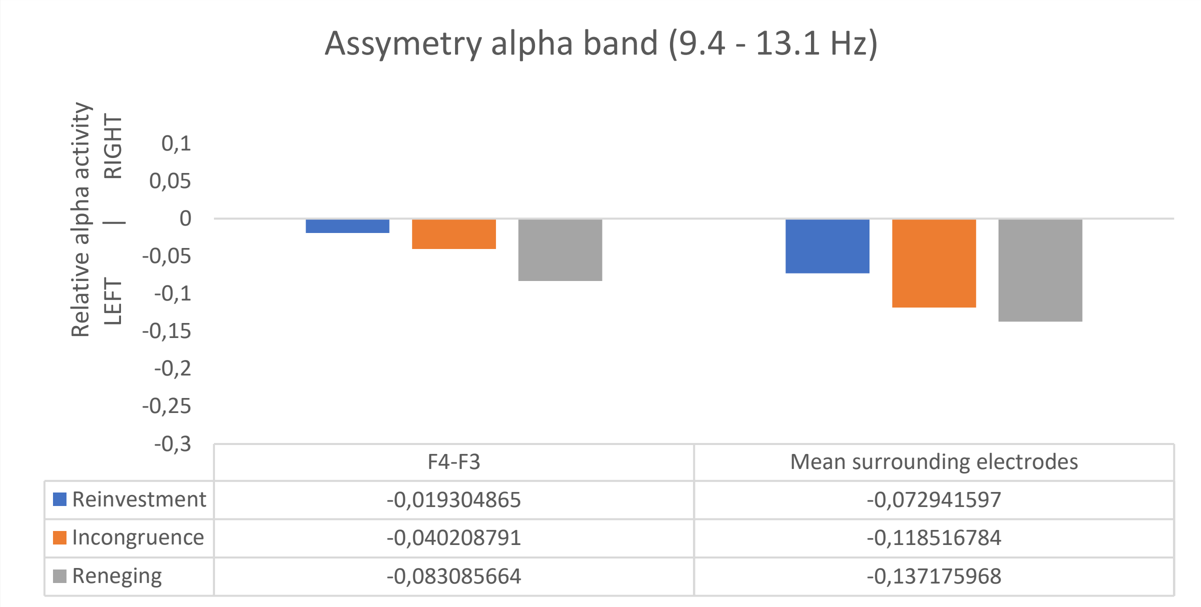
P-values of robust repeated measures ANOVAs on reinvestment, incongruence and reneging.

	4.7 - 6.5 Hz	**9.4 - 13.1 Hz**
C4	0.33693	
F3		0.63033
F4		0.28546

F4 it was reduced to 6.82μV², 95% CI [1.10, 12.5]. Moreover, a psychological contract breach based on reneging resulted in the greatest reduction of alpha activity in both F3 and F4. After breaches based on reneging F3 measured 6.30μV², 95% CI [1.65, 10.9] and F4 measured 5.80μV², 95% CI [1.89, 9.07]. The differences in power between the conditions in both F3 and F4 were statistically insignificant according to the output of robust repeated measures ANOVAs (see Table 4). The differences between conditions were assessed for every electrode, none showed statistically significant disparities, for the p-values of their robust repeated measures ANOVAs see appendix Table 2.

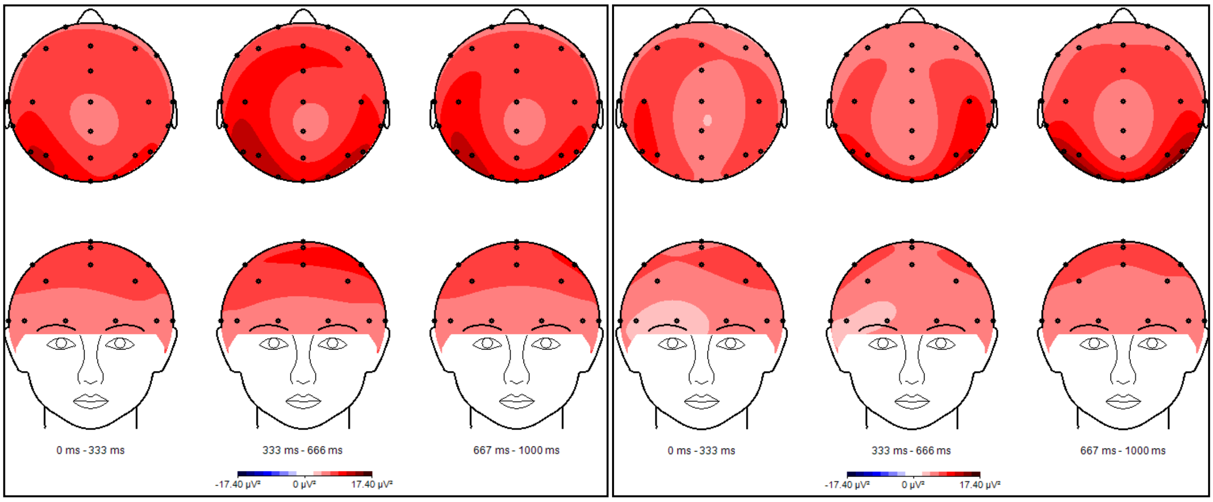
6.2 Relative asymmetry in the central and frontal regions

Figure 8 displays the output for the frontal asymmetry calculation based on alpha activity in F3-F4 and the mean of the electrodes surrounding the frontal region (Fp1-F7-C3 left; Fp2-F8-C4 right) during the three conditions. Negative asymmetry values indicate relatively stronger alpha power above the left frontal lobe in comparison to the right frontal lobe. Due to the inverse relationship with cortical activity, negative asymmetry values also indicate relatively



	F4-F3	Mean surrounding electrodes
Reinvestment	-0,019304865	-0,072941597
Incongruence	-0,040208791	-0,118516784
Reneging	-0,083085664	-0,137175968

Figure 8. The alpha asymmetry for each condition (reinvestment incongruence and reneging) based on alpha power. Alpha asymmetry was calculated in two ways: ln(F4)-ln(F3), on the right; and (ln(Fp2) + ln(F8) + ln(C4))/3 - (ln(Fp1) + ln(F7) + ln(C3))/3, on the left.



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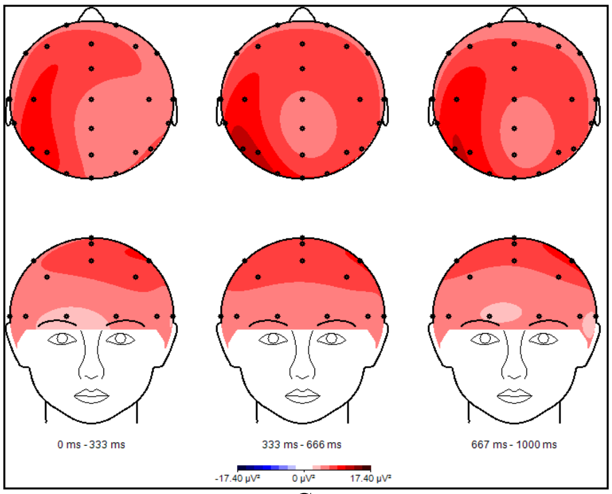

C

Figure 9. Top and frontal view topography of the alpha band, 9.4 - 13.1 Hz after presentation of the 3 stimuli (A reinvestment, B incongruence, C reneging). Data is displayed in 3 sections of 333ms ranging from 500ms until 1500ms. The scale ranges from -17.40 μV^2 to 17.40 μV^2.

stronger cortical activity above the right frontal lobe in comparison to the left frontal lobe. For both F3-F4 and the mean of surrounding electrodes the data shows an increase of relative right sided cortical activity during incongruence and reneging in comparison to investment. Additionally, the relative right sided cortical activity was highest during the display of the reneging symbol. Robust repeated measures ANOVAs indicated no significant asymmetry differences between the conditions in the asymmetries of F3-F4 (p-value: 0.74096) or the mean values created based on the surrounding electrodes (p-value: 0.52217).

In Figure 9 the topography of the alpha activity is shown. Note that the lighter red areas indicate higher cortical activity in comparison to the darker red, due to the inverted relationship between alpha and cortical activity. The topography provides additional information, the data of each condition is displayed over three periods (333ms each). This provides an overview of the development of brain activity during the presentation of the stimuli. None of the conditions displays a clear contrast between right and left frontal cortical activity. The topographies of the remaining frequency bands are similarly displayed in the appendix, Figures 1-3.

7 DISCUSSION

7.1 Discussion of findings

This study aimed to examine how trust and distrust in buyer-supplier relationships are influenced by psychological contracts. More specifically, neural correlates of trust and distrust were measured separately to alleviate the lack of literature that discusses distrust independent from trust (Guo et al., 2017). This study emerged from the necessity to obtain proper understanding of interpersonal dynamics in business-to-business relationships (Andersen & Kumar, 2006; Tähtinen & Blois, 2011). None of the statistical tests showed significant differences between the conditions. This may be due to the limited number of participants in this study. Regardless, this section discusses what the changes in brain activity and the direction of the effects might imply. An overview of how the direction of effects related to the hypotheses is provided in Table 5.

Table 5

Connection between the hypotheses, the expected data according to the hypotheses and the results.

Hypotheses	Expected power changes after the breach.	Measured data after the breach.
H1a: Following a psychological contract breach, trust decreases.	A reduction in left sided frontal cortical activity and right sided central theta activity.	There was an increase of left sided cortical activity and a reduction of right sided central theta activity.
H1b: Following a psychological contract breach, distrust increases.	An increase of right frontal cortical activity.	Frontal cortical activity increased.
H2: A psychological contract breach based on reneging leads to a more pronounced increase in distrust compared to a psychological contract breach based on incongruence.	A more pronounced increase in right frontal cortical activity after a psychological contract breach based on reneging in comparison to incongruence.	The increase in right frontal cortical activity was more pronounced after a psychological contract breach based on reneging in comparison to incongruence.

The right central theta activity measured with electrode C4 showed high power prior to the breach. The theta power decreased slightly after the incongruence breaches, whereas reneging breaches provoked a greater decrease. Based on the correlation between theta activity and trust presented by Vecchiato et al. (2014), the reduction of theta activity may indicate a reduction of trust after the psychological contract breaches. Therefore the direction of the effect in theta waves is in alignment with H1a. However, as mentioned earlier, Vecchiato et al. (2014) are the only scholars that have found this correlation in a location of function study. Therefore cautious interpretation regarding these results is advised. More location of function studies are needed to verify this correlation. Additionally, a clear explanation as to why this region may be correlated with trust missing.

Both electrodes in the frontal region (F3 and F4) were assessed independently and both showed a decrease in alpha activity after psychological contract breaches. As mentioned earlier, overall, alpha activity is high during relaxed states, the overall decrease in alpha activity may signal an increase in alertness (Braboszcz & Delorme, 2011). The decrease in alpha activity signals an increase of cortical activity in both hemispheres after the breach. The increase of cortical activity in the left frontal region may indicate an increase of trust after the breach. Therefore the direction of effects is in contrast with H1a. Next to an increase in awareness, a possible explanation for the unexpected rise in left frontal cortical activity in the case of a contract breach may be that participants experienced feelings of anger (Peterson et al., 2011; Peterson et al., 2008). As noted earlier, in contrast to other emotions linked to distrust, anger is an emotion linked to approach-behaviour and thus left frontal activity (Berkowitz & Harmon-Jones, 2004; Carver & Harmon-Jones, 2009). Future research may address the influence of anger by using a traditional behavioural methods next to the neuroscientific methods, for example, a Likert scale.

The increase of cortical activity in the right frontal region (F4) implies an increase of distrust after the breach. Therefore, the change in right frontal cortical activity supports H1b. Moreover, right cortical activity increased more after reneging breaches in comparison to incongruence breaches. Which insinuates that breaches based on reneging lead to more pronounced increases of distrust, in support of H2.

Furthermore, the relative cortical asymmetry analysis was used to assess whether the relationship between the neural correlates for trust and distrust shifted. Prior to the breach the right hemisphere displayed a stronger activity level. After the psychological breaches, the gap between right and left frontal cortical activity increased. These findings support H1b and H2 because relative right cortical activity is linked to distrust. Put differently, the data suggests that psychological contract breaches lead to more distrust in comparison to trust and distrust is most pronounced after a psychological contract breach based on reneging.

In sum, the results in this study indicate that neither trust nor distrust is affected by psychological contract breaches at a statistically significant level. However, because the low number of participants may have caused the lack of statistical significance, the effect directions were assessed. The changes in theta activity support H1a, yet the alpha power does not support H1a. The alpha activity and frontal asymmetry are in alignment with H1b and H2.

7.2 Implications for literature

Based on the directions of effects this study provides various implications for purchasing literature and frontal asymmetry literature. Firstly, by suggesting that a psychological contract breach enables a shift towards low trust and high distrust, this study reveals more details on previously established correlations in SCM literature. To visualize this impact consider the relationship between trust and distrust and information sharing in a supply chain. As mentioned earlier and often discussed in SCM literature, information sharing is a consequence of trust (Brenkert, 1998; Han et al., 2021; Mirkovski et al., 2019). However, information sharing may still be present in relationships with low trust, whereas, high distrust strongly discourages information sharing (Cho, 2006). Because this study aimed to measure the impact psychological contract breaches on trust and distrust separately, more propositions can be derived from the previously shrouded relationship between psychological contract breaches and information sharing. Namely, psychological contract breaches lead to a decrease in information sharing, because psychological contract breaches lead to a shift towards high distrust in supply relationships. Similar connections could be made based on all variables that are differently influenced by high trust and low distrust or low trust and high distrust (e.g., see the 'consequences' section in Table 1), providing new depth to previous literature. Currently, a considerable amount of business-to-business research overlooks pertinent findings by failing to investigate distrust or differentiate between trust and distrust (e.g., Biedenbach et al., 2019; Eckerd et al., 2016; Høgevold et al., 2020).

Secondly, this study highlights the importance of considering intentionality in SCM literature. While the discrepancies between incongruence and reneging in psychological contracts are researched occasionally, it is far from a standard practise to acknowledge the distinction (e.g., Asante et al., 2023; Lim et al., 2023; Said et al., 2021; Sandhya & Sulphey, 2020; Soares & Mosquera, 2019). The data in this study suggests that reneging psychological contract breaches have a different (more pronounced) effect on distrust in comparison to incongruence psychological contract breaches. Therefore, the intentionality of psychological contract breaches may have an indirect effect on previously researched relational SCM factors. For example, in their study on trust and distrust in supply chains, Han et al. (2021) stated that distrust is linked to a reduction of opportunism and increases of the importance of control mechanisms. This may indicate that reneging psychological contract breaches could lead to lower opportunism and greater control mechanisms in the supply chain.

Thirdly, although the main objective of this study was not to prove that trust and distrust can be measured separately through neuroscience, by utilizing this methodology it highlights the possibilities and challenges of such an approach. It showed that even with neuroscientific methods, such a separate identification is not as readily obtainable as may be expected. This is partly because the neural correlates of mental phenomena are just correlated with the mental phenomena and thus not equal to the mental phenomenon itself. Regardless, the use of different neural correlates to measure these constructs does aid the literature on their separation. Based on the results obtained, it is impossible to say whether trust and distrust are indeed separate constructs. However, by extending on this methodology with traditional behavioural methods, future studies could obtain more clarity on the matter. Therefore, it provides a pathway to future SCM literature that aims to investigate the effect of cognitive processes through neuroscience in the supply chain. Some suggestions on how future SCM literature may be able to build on this research and obtain a more clear separation of trust and distrust with neuroscientific (and traditional behavioural) research methods is discussed in section 7.3.

Fourthly, by aiming to measure trust and distrust separately, it contributes to the SCM literature by extending on a more nuanced platform on which classic SCM theories such as transaction-cost-economics can be applied in future studies (see Han et al., 2021). This more nuanced platform is crucial to the future of SCM literature because identifying both trust and distrust separately helps in understanding the possibilities within business relationships. The prevailing focus on trust without distrust decreases the usefulness of the findings, because certain facets of a relationship are influenced more by trust and others are more susceptible to distrust. Aside from overlooking some implications of their findings, studies may incorrectly attribute effects of changes in distrust levels to changes of trust levels.

Fifthly, this study also provides insights in various phenomena related to frontal asymmetry literature. The valence and motivational direction paradigms usually align in frontal asymmetry literature. However, it is still debated if valence and motivational direction align coincidentally and therefore only one of them is actually correlated with frontal asymmetry. This debate arose simultaneously with the debate on anger, which fits in both negative valence and approach behaviour (contrary to most emotions). Harmon-Jones et al. (2022) extensively discussed literature on the debate. For example, they mentioned that anger in absence of approach motivation still increases left frontal cortical activity (Harmon-Jones, 2003). However, if approach motivation is simultaneously present the level of left cortical activity increases to higher amounts (Harmon-Jones, 2006). Anger only leads to right frontal cortical activity if participants fear the social consequences of their expression of anger (Zinner et al., 2008). In general these findings seem to implicate that motivational direction dominates over valence but that they are both correlated with frontal asymmetry. The data obtained in this study is relevant for the discussion because the unexpected increase in left cortical activity also points to the dominance of motivational direction over valence.

Finally, the study highlights various cognitive neuroscience practices, which if omitted can reduce replicability and meaningfulness of EEG results. For example, the collapsed localizer approach is not always used and thus discussion on which timeframe is relevant to the findings is sometimes lacking (e.g., Oh et al., 2022). This study provides a framework for the application of cognitive neuroscience in business contexts, enabling new insights that may not be accessible through traditional behavioural research methods.

7.3 Limitations and future research directions

This study is limited by various factors which provides opportunities for future research. Firstly, the differences detected between the conditions are not statistically significant. This may have been caused by a lack of engagement. As stated previously, the maximum obtainable reward was significantly lower compared to some previous studies. However, it is more likely a result of the low number of participants within this study. Since relevant EEG data may only be a millionth of a volt or a hundredth of a second these effects can be easily masked by the diverse disturbances of biological (e.g., mind wandering) and environmental (e.g., luminance) origin (Luck & Gaspelin, 2017). This is a well-established problem which among other reasons results in low reproducibility in neuroscience literature (Button et al., 2013). Future research could negate this problem by increasing the number of participants to a minimum of 18. This counterbalances the problem because averaging over larger numbers reduces the variance unrelated to the differences between the conditions tested and increases the chance of detecting a true effect (Button et al., 2013).

Secondly, while this study tried to optimally recreate the intricacies of buyer-supplier relationships without overcomplicating the interpretation of EEG signals, future research can expand on the constrained scope used in this research. For example, relational psychological contracts and cultural differences are not incorporated within this study. While it is argued that cultural barriers have an impact on trust in buyer-supplier relationships (Ribbink & Grimm, 2014) and willingness to continue purchase behaviours after a psychological contract breach (Eckerd et al., 2016). Furthermore, participants could only relate to their role, professional buyer, through the basic instructions and explanations provided before the experiment. Professional buyers, playing in more sophisticated simulations, which incorporate a larger part of actual business-to-business relationships may provide more accurate insights in future research.

Thirdly, Tomlinson and Lewicki (2006) argued that distrust may be influenced by the number of previous expectation violations. Implications resulting from the recurrence of breaches were lost within this study due to the averaging of data regardless of the number of prior contract breaches. Upcoming studies may want to include such factors in their analysis by obtaining a sample size large enough to enable averaging solely between participants instead of within and between participants.

Fourthly, as discussed earlier, using reverse inferencing assumes that if a task is carried out, a specific brain region is reliably activated, and a cognitive process has been linked to that brain region by a prior localization of function (Poldrack, 2006). However, this assumption does not consider that other mental processes can activate the same brain region (see appendix Table 1). The measured power may originate from different sources. For example, measurement of oscillations in C4 may have been plagued by its location directly above the primary motor cortex, which controls the left hand. Therefore, nonexistence of activity in a brain region can be interpreted as the absence of a cognitive process. However, a decreased amount of activity only lowers the probability that a cognitive process is present. Moreover, while cognitive neuroscience literature often simplifies a cognitive process and the linked brain activity to one and the same, the two are merely connected by correlating behaviour (Lindebaum & Jordan, 2014).

Finally, in hindsight the interpretation of EEG values could have been simplified by using a neutral condition and complimentary traditional behavioural research methods. The neutral position with no trust and no distrust, may have provided a better baseline. By using complimentary traditional behaviour research methods this research could have better informed literature on the correlations between the brain regions associated with trust and distrust and the actual mental processes of trust and distrust. This may have enabled a more straightforward conclusion to the following research question: *can trust and distrust be effectively measured using brain activity, specifically within the frontal lobes?* Once this research question is answered in future research, the results of this study will hold more meaning. In this study it is argued that based on previous location of function studies, there is a correlation between the frontal lobes and trust and therefore the measurement of trust and distrust through EEG is possible. However, retesting the correlation between the brain regions and the mental phenomena through complementary behavioural methods provides a stronger argument and creates a higher level of resilience to confounding elements and misinterpretation of brain activity.

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APPENDIX

Table 1

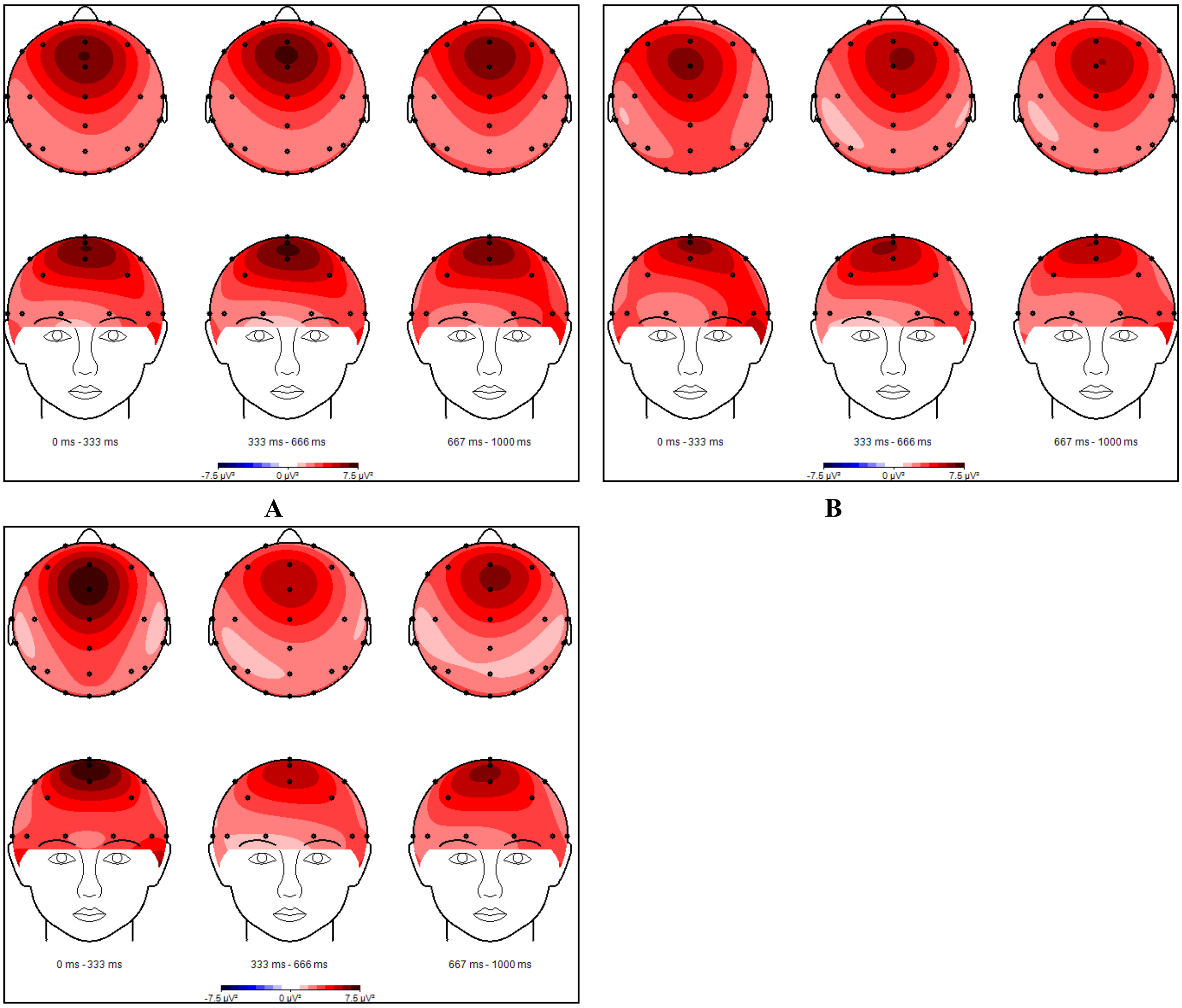
Examples of brain functions associated with the relevant brain regions.

Authors	Study	neural correlate	Associated with
Chen & Rappelsberger, 1994	Brain and human pain: topographic EEG amplitude and coherence mapping.	Central region	Human pain
Teplan et al., 2006	EEG responses to long-term audio–visual stimulation.	Central region	Long-term audio-visual stimulation
Grunwald et al., 1999	Power of theta waves in the EEG of human subjects increases during recall of haptic information.	Frontocentral region	working memory
Yun et al., 2008	Emotional interactions in human decision making using EEG hyperscanning.	Frontocentral region	social decision-making
Fox, 1991	If it's not left, it's right: Electroencephalograph asymmetry and the development of emotion.	Left frontal region	directional component of emotions (approach and explore)
Morris et al., 1993	Neural correlates of planning ability: frontal lobe activation during the Tower of London test.	Left frontal region	planning activities
Schmidt & Trainor, 2001	Frontal brain electrical activity (EEG) distinguishes valence and intensity of musical emotions.	Left frontal region	experiencing happiness and joy through a musical medium
Moran et al., 2004	Neural correlates of humor detection and appreciation.	Left frontal region	humour detection
Fiori et al., 2014	"If two witches would watch two watches, which witch would watch which watch?" tDCS over the left frontal region modulates tongue twister repetition in healthy subjects.	Left frontal region	speech repetition
Fox, 1991	If it's not left, it's right: Electroencephalograph asymmetry and the development of emotion.	Right frontal region	directional component of emotions (withdraw and flee, disgust)
Kang et al., 1991	Frontal brain asymmetry and immune function.	Right frontal region	stimulation of killer cells production
Shammi & Stuss, 1999	Humour appreciation: a role of the right frontal lobe.	Right frontal region	humour appreciation

Table 2

P-values of robust repeated ANOVAs.

	4.7 - 6.5 Hz	**6.6 - 9.3 Hz**	**9.4 - 13.1 Hz**	**13.2 - 18.6 Hz**
FP1	0.47242	0.59569	0.29780	0.40474
FP2	0.62614	0.70979	0.67195	0.42567
F7	0.51212	0.79356	0.49194	0.60420
F3	0.46765	0.41497	0.63033	0.46845
Fz	0.83431	0.43643	0.57571	0.37490
Fcz	0.85234	0.43538	0.50873	0.34269
F4	0.58162	0.79650	0.28546	0.48295
F8	0.35566	0.34023	0.49764	0.58561
T7	0.59374	0.27912	0.17545	0.27149
C3	0.65572	0.37844	0.34128	0.47496
Cz	0.55749	0.40309	0.46662	0.32171
C4	0.33693	0.56035	0.66699	0.47531
T8	0.85886	0.28202	0.50728	0.26877
TP9	0.66530	0.41897	0.50456	0.67875
TP7	0.78697	0.35597	0.54986	0.47167
Cpz	0.66278	0.20733	0.67798	0.17675
TP8	0.47797	0.09095	0.30657	0.44329
TP10	0.62743	0.35109	0.22440	0.53345
P5	0.68031	0.64560	0.94344	0.34933
P3	0.61351	0.49432	0.57364	0.66387
Pz	0.35388	0.36920	0.64179	0.10594
P4	0.88416	0.68471	0.39638	0.72332
P6	0.83104	0.59441	0.50890	0.56721
O1	0.27582	0.36474	0.59476	0.53740
Oz	0.24042	0.41398	0.03118	0.63049
O2	0.68211	0.37889	0.36769	0.63885



C

Figure 1. Top and frontal view topography of the theta band, 4.7 - 6.5 Hz (A reinvestment, B incongruence, C reneging). Data is displayed in 3 sections of 333ms ranging from 500ms until 1500ms. The scale ranges from -7.5 µV to 7.5 µV.

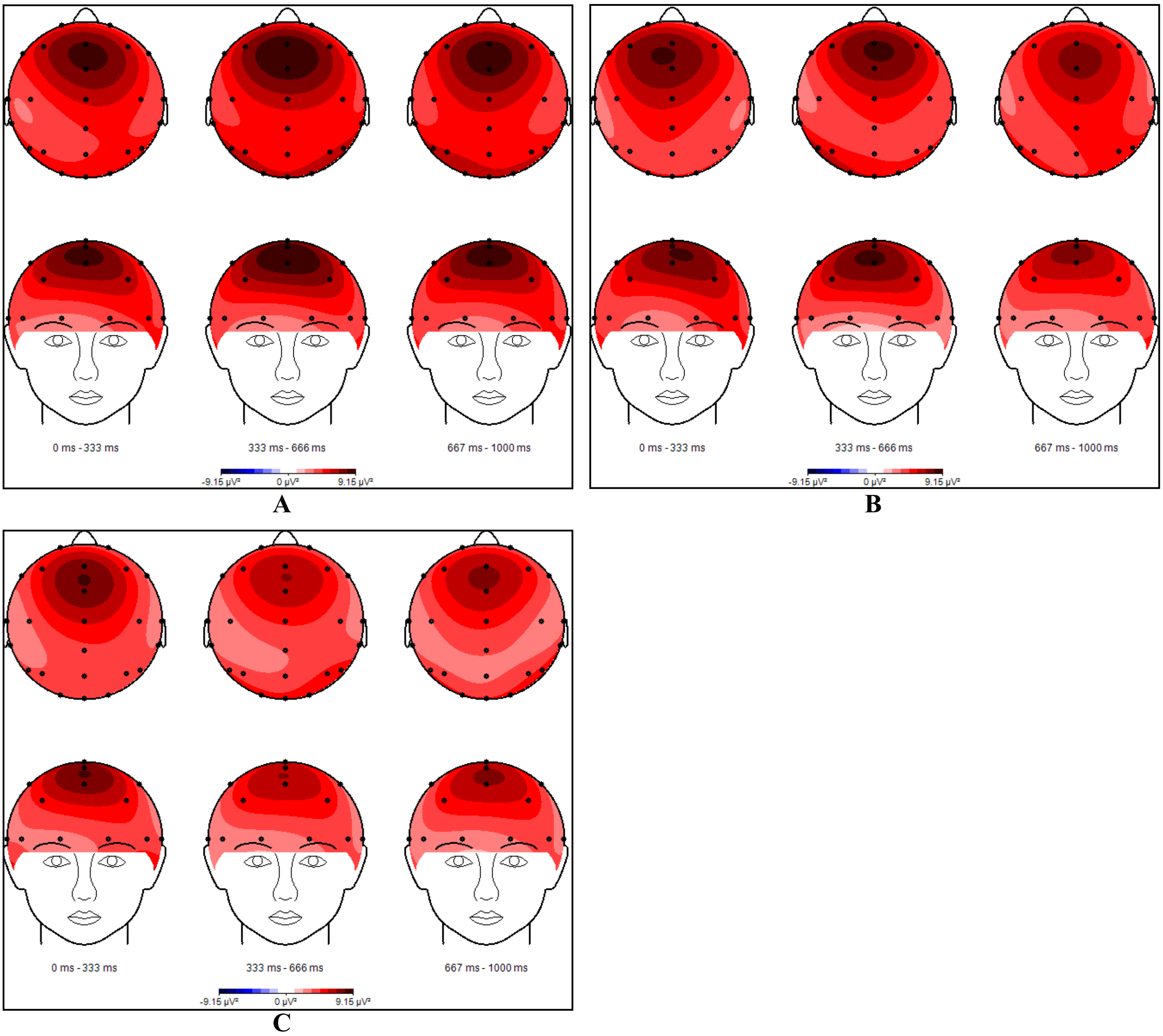
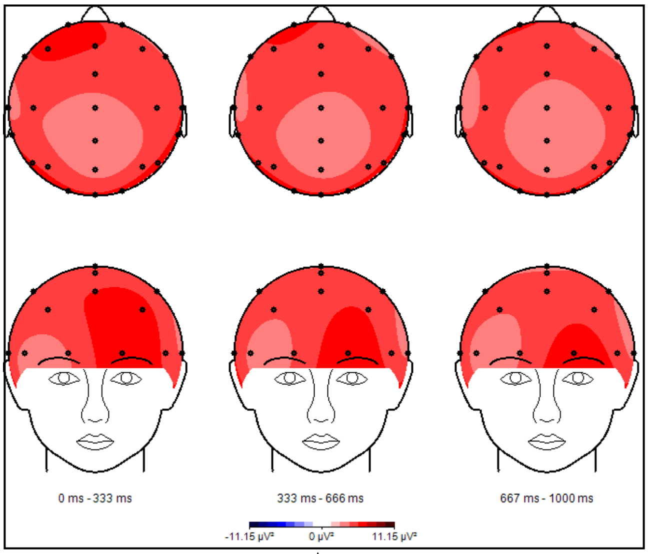
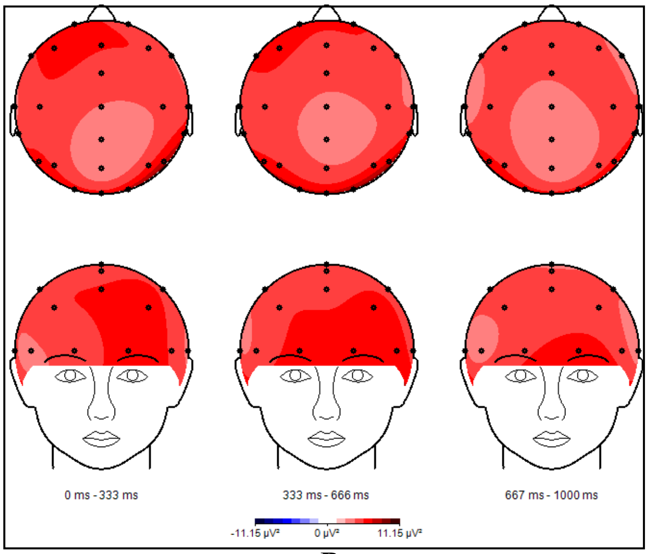


Figure 2. Top and frontal view topography of the theta band, 6.6 - 9.3 Hz (A reinvestment, B incongruence, C reneging). Data is displayed in 3 sections of 333ms ranging from 500ms until 1500ms. The scale ranges from -9.15 µV to 9.15 µV.



A



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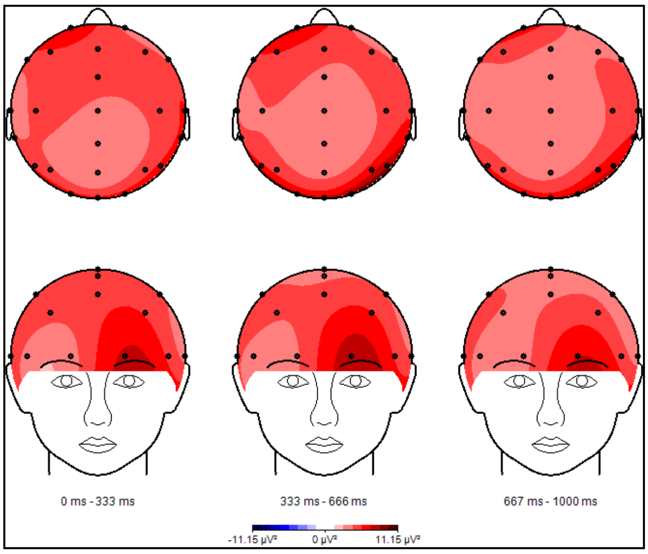

C

Figure 3. Top and frontal view topography of the beta band, 13.2 - 18.6 Hz (A reinvestment, B incongruence, C reneging). Data is displayed in 3 sections of 333ms ranging from 500ms until 1500ms. The scale ranges from -11.15 µV to 11.15 µV.