Humans do not reason from contradictory premises. The psychological aspects of paraconsistency.

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Abstract The creation of paraconsistent logics have expanded the boundaries of formal logic by introducing coherent systems that tolerate contradictions without triviality. Thanks to their novel approach and rigorous formalization they have already found many applications in computer science, linguistics and mathematics. As a natural next step, some philosophers have also tried to answer the question if human everyday reasoning could be accurately modelled with paraconsistent logics. The purpose of this article is to argue against the notion that human reasoning is paraconsistent. Numerous findings in the area of cognitive psychology and cognitive neuroscience go against the hypothesis that humans tolerate contradictions in their inferences. Humans experience severe stress and confusion when confronted with contradictions (i.e., the so-called cognitive dissonance). Experiments on the ways in which humans process contradictions point out that the first thing humans do is remove or modify one of the contradictory statements. From an evolutionary perspective, contradiction is useless and even more dangerous than lack of information because it takes up resources to process. Furthermore, it appears that when logicians, anthropologists or psychologists provide examples of contradictions in human culture and behaviour, their examples very rarely take the form of: $(p \land \neg p)$. Instead, they are often conditional statements, probabilistic judgments, metaphors or seemingly incompatible beliefs. At different points in time humans are definitely able to hold contradictory beliefs, but within one reasoning leading to a particular behaviour, contradiction is never tolerated.

Keywords contradiction · paraconsistency · inconsistency · dialetheism · reasoning · psychologism · cognitive dissonance

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1 Introduction

> *"'From a contradiction everything would follow.' The reply to that is: Well then, don't draw any conclusions from a contradiction."*
> -Ludwig Wittgenstein, 1939.

Contradiction is one of the most central concepts to logic and philosophy. Most paradoxes cherished by philosophers have a contradiction at their heart, while proof by contradiction is one of the classic methods for proving theorems in logic. In classical logic the principle of explosion states that from a set that contains contradictory premises, everything follows. As a result, in classical logic nothing meaningful can ever be derived from a contradiction. At the same time, contradictory ideas seem to be widely present across all human cultures since the dawn of time (Berliner et al. 2016).

Because contradictions are so widely present in the culture and because people seem to be able to deal with them so well in their everyday life, logicians decided to reflect on the principle of explosion and applicability of classical logic to human everyday thinking. The explosion principle states that every statement can be inferred from a contradiction, but the psychology of human behaviour did not present any data whatsoever that would show that humans somehow satisfy it in their cognition. After all, at first glance it may seem that humans are able to relatively effortlessly hold contradictory beliefs without a cognitive overload. As a result, a deceptively alluring idea was born – that humans reason from contradictory premises in their everyday thinking. A need arose for the principle of explosion to be suspended when considering human reasoning processes. That gave rise the attempts at applying paraconsistent logics to human thinking.

The aim of this article is to critically analyse the claim that humans tolerate inconsistencies or contradictions in their thinking. I will argue that humans do not reason from contradictory premises. Instead, they resolve contradictions with a variety of strategies that allow them to partition contradictory beliefs into separate, consistent sets of premises. Furthermore, I will point out that numerous so-called contradictions analysed in the literature are not contradictions in the strict sense of the word. Instead, they tend to be conditional statements, probabilistic judgments, metaphors or merely seemingly incompatible beliefs, while at their core never assuming the form of: *It is the case that p and it is the case that ¬p.* We will analyse psychological and logical works that used the idea of humans reasoning from contradictions as a central point for their considerations. It is important to highlight that the aim of this paper is not to argue against dialetheism or the usefulness of paraconsistent

logics. It is merely to refute the claim that contradictions are often starting points for everyday human inferences.

2 Logical aspects

Etymologically speaking, the word *"contradiction"* comes from the Latin *"contradicere,"* where the prefix *"contra"* means *"opposite"* and the verb *"dicere"* means *"to say."* As a result, the word expresses a notion of: *"saying the opposite."* In the simplest terms, in classical logic a set of propositions X is contradictory if and only if for any proposition p, $X \vdash p$, which means that the set X satisfies the relation: $X \vdash p$ for all p. In other words, any proposition can be derived from a contradiction, which is called *the principle of explosion* or *ex falso quodlibet.*

In more human terms, a contradiction is a pair of propositions that cannot both be true at the same time and cannot both be false at the same time. That formulation can also be called the law of non-contradiction: $\neg(p \wedge \neg p)$. The other two "laws of thought" that delineate the boundaries of contradictions are the law of identity and the law of excluded middle. The law of identity states that *"Everything is what it is"* (i.e., $a = a$)[1], while the law of excluded middle states that in a pair of propositions $p, \neg p$, either one of them has to be true.

Ontologically, contradictions are linguistic/logical representations of impossibilities: facts that cannot co-occur. Conveniently, contradictions can also be defined in terms of models or possible worlds (Novaes 2007): for a contradictory A and B, there is no such model or possible world M such that $M \models A$ and $M \models B$ and there is no such model or possible world M' such that $M' \models \neg A$ and $M' \models \neg B$.

The existence of contradictions has always been of critical importance for mathematics, logic and philosophy. One of the most popular proof types in these disciplines is the "proof by contradiction." It is a straightforward procedure, where we assume the tested proposition p to be false. Then, if $\neg p \vdash q \wedge \neg q$, then because q and $\neg q$ cannot both be true, we conclude that: $\neg(\neg p)$.[2] The importance of contradictions is also evident when considering that paradoxes are propositions which lead to circular, contradictory conclusions (Łukowski 2011).

The law of non-contradiction has had many formulations across history. The most influential work on these formulations was published by Ignacy Łukasiewicz in 1910. In his publication entitled *"On the principle of contradiction in Aristotle"*[3] he reinterpreted the ways in which Aristotle described the law of non-contradiction. Łukasiewicz found that the Stagirite spelled out

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[1] a in the law of identity is understood as a single term rather than a proposition.

[2] This type of proof is called "non-constructive", in opposition to "constructive" proof, which is stronger.

[3] Originally published in Polish under the title: *"O zasadzie sprzeczności u Arystotelesa. Studium krytyczne."*

three substantially different formulations. The first one, called "ontological" addressed physical reality: *"To no object can the same characteristic belong and not belong at the same time."* The second one, called "logical" concerned propositions: *"Two conflicting (contradictory) propositions cannot be true at the same time."* Finally, and most interestingly for this work, Aristotle provided us with a third formulation that referred to the human mind, which Łukasiewicz dubbed as "psychological." A direct translation of the relevant part of Metaphysics yields:

"No one can believe that the same thing is and is not (as some would claim Heraclitus said), because the speaker does not have to believe what he says."
(Aristotle, trans. 1910)

Łukasiewicz (1910, p. 11-13) reformulated it as follows: *"Two acts of believing which correspond to two contradictory propositions cannot obtain in the same consciousness."*[4] This view of the law of non-contradiction has been heavily criticised for "psychologising" Aristotle's thought and logicians sought to find translations that would rid this formulation from the aspects that pertain to mind, subjectivity and interlocution (Pietryga 2004; Stuchliński 1994). For example, in such attempts, Stuchliński (1994) produced an alternative formulation that states: *"A person X in time t does not acknowledge the sentence: S and not-S as true in language L."* (Stuchliński 1994, p. 49). Despite the fact that these authors denounced psychologism and explicitly tried to "defend" Aristotle from being interpreted from psychological perspective, their work retained language referring to the human mind. In fact, their formulations of the non-contradiction principle can even be used to formulate testable, empirical hypotheses.

The key to the relevance of psychological law of non-contradiction for empirical psychology are the verbs or verbal nouns it contains: *"believe,"* *"convictions,"* or *"acknowledge."* The law does not state that humans are unable to process contradictions whatsoever. We are obviously able to store contradictory statements in our working memory and perform inferences separately for p and $\neg p$[5]. After training, paraconsistent logicians may even apply some of their principles and *"slowly"*[6] infer conclusions from inconsistent premises. However, what appears to be impossible is to fully *believe* two truly contradictory statements. For the purpose of this work we will define "belief" very conservatively and reductively as: *A statement is believed if it is used as a premise for an inference performed in decision making*[7] Merely using a statement for an inference cannot be considered belief, because people are able to easily reason in terms of possible worlds (i.e., counterfactual reasoning) and

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[4] As translated by Vernon Wedin in 1971.

[5] In logic such an act would be described in terms of reasoning about *"possible worlds,"* whereas in psychology such reasonings are called: *"counterfactual reasonings"* (Roese 1997).

[6] *"Slowly"* in terms of the *"slow thinking,"* described by Daniel Kahneman (2011) as deliberative, highly conscious and logical form of thinking.

[7] This definition is a practical version of the popular in philosophy way of defining "belief" as an attitude of regarding something as true (Schwitzgebel 2019 -Stanford).

pretend to adopt beliefs that they do not truly endorse. Thus, a situation in which an inference is performed has to be related to the content of the premise that is a candidate for being a belief. In other words, beliefs are those propositions that influence human behaviour. For example, if a person is told that the door in front of them will lead them outside and it will not lead them outside (contradiction), a belief check would happen if they actually had to go outside and make a decision if they should use the door. What do people do when such circumstances occur? The answer to that question has already been extensively studied by psychologists (see section 2).

Because of the principle of explosion, contradictions tend to be the endpoints for logical inferences in classical logic. Falsity of propositions is proven by showing with a logically valid reasoning that they lead to a contradiction. Since everything follows from a contradiction, therefore an inconsistent set of premises is useless. However, contradictions are seemingly omnipresent in human thinking, language, culture and behaviour (Berliner et al. 2016, Spencer-Rogers et al. 2009, Fletcher & Olwyler 1997). Some philosophers argued that humans tolerate and perform inferences from contradictions and that classical logic does not represent the structure of human thinking. A need arose to adopt systems that would formalize seemingly inconsistent human thinking and abandon the principle of explosion. For example, Luchins & Luchins (1965, p. 62-63) wrote:

"Although traditional logic has proved to be a useful model of thinking, it may not encompass all aspects of thinking. Just as, for certain purposes (e.g. relativity theory), it is useful to apply non-Euclidean geometry even though Euclidean geometry serves adequately as a model for earth measurement; so it may be worthwhile to apply models of logic other than traditional logic to human thinking."

The need for such systems was answered between 1910 when Łukasiewicz published his work on the principle of non-contradiction by Aristotle, to 1976 when Miro Quesada proposed the name: *"paraconsistent logics"* (Costa et al. 1995). Such logics reject the principle of non-contradiction and employ a weakened version of the negation connective (Béziau 1999, p. 14)[8] Of course, they were not created solely in the XXth century, but instead are a product of a long history of logical and philosophical works analysing the *ex falso quodlibet* principle and the properties of the negation and implication connectives. Paraconsistent logics allow the existence of some inconsistent sets of premises without "exploding." However, it is important to note that they do not permit every possible inconsistent set of premises, as that would make them trivial (Novaes 2007). Contradictions are allowed, but only under certain conditions, which every paraconsistent logic attempts to delineate.

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[8] Some logicians posit that paraconsistent logics are based on a misunderstanding or fallacy, since they argue that negation which does not obey the law of non-cotradiction is not really a negation (Quine 1970; Slater 1995). In our work we assume that paraconsistent logics successfully achieve what they claim.

For example, in the logic of Kolmogorov or minimal logic of Johansson there are some affirmative propositions that do not follow from any contradiction, however any negation still always follows from any contradiction. In Jaśkowski's discussive logic, contradiction in the form: $(p \wedge \neg p)$ does not "explode," but a contradiction that takes the form of: $\neg(p \vee \neg p)$ does, even though in classical logic it is equivalent to: $(p \wedge \neg p)$. A different approach was taken by Nikolai Vasiliev who laid foundations for a logic [9] where the contradiction $(p \wedge \neg p)$ trivializes a system, unless the proposition p is a special "Vasiliev variable." Evidently, different logicians employed different ways of rejecting non-contradiction, which stems from the fact that they also differed in motivations and goals for applying their systems.

Two main motivations guided the hand of the logicians who created paraconsistent logics. First, pure freedom of the mathematician or logician to devise systems with arbitrary constraints, which may later find their way into applied science. Second, the reflection that apparent contradictions are everywhere around us and that treating them as anomalies may not be the best way to go.

With regard to the first motivation, the proponents of paraconsistency are very explicit. Costa et al. (1995, p. 115-116) writes:

> "(. . .) we wish to point out that, from our viewpoint, when presenting a formal system, one does not need to be concerned with the formulation of philosophical rationales for the mathematical constraints introduced. (. . .) Moreover, such systems are not thought of as capturing the true nature of the world, nor of logic, of logicality or whatever. In the first instance, they were just devised with the aim of putting forward a particular logical system meeting certain theoretical constraints. Could such constraints be changed? Of course, as in fact they have already been with the formulation of alternative systems."

As a result, it is imperative to remember that paraconsistent logics cannot be criticised on the grounds of being inapplicable to some practical issues, like human thinking for example. Paraconsistent logics were created with the intention of being arbitrary logical systems which means that justification of their applicability to any given problem is the task of philosophers and scientists who study that problem. The aim of this work is therefore to argue for a limited applicability of paraconsistent logics to human everyday thinking. Jean-Yves Béziau (1999, p. 14) who is one of the most important researchers of paraconsistency leaves its applicability to human thinking as an open question:

> "Given a human being like John Smith, with contradictory desires and wills, can we think that it is his normal state, that John Smith behaves in a paraconsistent way and that paraconsistent logic is the adequate tool to describe his behaviour? Or must we think that these contradictions are a kind of disease that should be eliminated, for John Smith recovering his health, following again the pattern of classical logic"

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[9] Formalized by Ayda Arruda in 1977.

The fathers of paraconsistent logics are very stern in their stance that their logics are not meant to replace classical logic (Costa et al. 2005). They see paraconsistent logics merely as tools that should be used wherever they fit better for their purpose than other types of logic.

However, some philosophers are much less conservative about the scope that paraconsistent logic should cover and postulate it as the 'go-to' system when analysing natural language production (McGinnis 2013). For example, Megill (2004) argued that *"we are in fact paraconsistent"* in the context of an ongoing debate regarding the nature of the human mind. Computational Theory of Mind holds that human minds are Turing machines, but that view came under scrutiny for many different reasons. One of them was our apparent resilience to the Gödel's theorem. Megill (2004) posits that humans are able to decide the truth of the Gödel's sentence because they are Turing machines that do not employ classical logic as a principle of fuction, but instead use paraconsistent logic (Megill argues mostly for relevance logic). In his arguments he does not hesitate to refer to the reality of human thinking (Megill 2004, p. 27):

"The phenomenon of belief revision also suggests that we use paraconsistent reasoning (. . .). We believe something because we think it true, yet, humbly, we do allow for the possibility that at least one of our beliefs could be—and probably is—false; if we didn't allow for this possibility, it's hard to see how belief revision would even be possible (. . .)"

The claim that belief revision in humans requires paraconsistent reasoning is not true and we will discuss that in the next sections. However, such a claim could also be dispelled by simply pointing out that classical computer programs operating by the principles of classical logic have no problems updating their memory with new information and deleting obsolete, old information, without resorting to paraconsistency. Imagine a simple robot with a camera. Within its memory it contains information that a hat is on the table. If upon an inspection of the table it would find no hat there, it would update its information (belief?) and now store information that there is no hat on the table. No one would accuse the creator of the robot of using paraconsistent logic in their computer code. That view on belief revision would be heavily criticised by one of the fathers of praconsistent logics and dialetheism, Graham Priest. For example, in 2008 he presented a comprehensive interpretation of belief revision through the lens of paraconsistent logic (Priest, 2008).

The common belief that everyday human reasoning does not abide by the rules of classical logic naturally generates theories addressing the question: what type of logic does it abide by? Philosophers and scientists try to characterize human thinking by finding the rules of inference that humans really follow. Unfortunately, the surface appearances of everyday conclusions that people make in their lives, led many researchers to believe that human reasoning is non-monotonic, paracomplete and paraconsistent. In fact, this idea is strong enough, that when cognitive scientists try to devise a system that

accurately captures human inferences, they use non-monotonicity and para-consistency as main goals to be achieved by that system (Anderson et al. 2013).

In the next section we will analyse evidence against such a view of human cognition. We will point out that the existence of contradictions in the human mind broadly understood does not mean that it performs paraconsistent reasonings.

3 Psychological aspects

The most brutal and straightforward way of researching how human cognition reacts to a contradiction is to present people with contradictory statements and ask them for their understanding of them. That was done by Sharpe & Lacroix in 1999. The experimenters examined 24 adults and 48 children (aged 3-8) and told them a story about two people having dinner. After the meal, one person asked the other: *"Did you like your supper?"*, to which the other person replied: *"Yes and no. I liked my supper and I didn't like it."* Participants of the study were asked what did the second person mean with their response.

Every single participant of the study reinterpreted the reply in a way that removes the apparent contradiction. Most of them (approximately 70%) got rid of the contradiction by addressing the meaning of the word *"supper"* and taking advantage of its generality. They assumed that the person giving the reply meant that they liked one part of the supper but did not like another part. However, some participants of the study used different strategies. Some addressed the vagueness of the word *"like"* and pointed out that perhaps the supper was average, so the person neither liked it very much nor disliked it very much. Others bluntly dismissed the whole reply and stated that the person must have disliked the supper but was just trying to be polite. The authors interpreted their results by stating that humans must be using some "non-classical" forms of inference that helps them resolve contradictions. The proponents of paraconsistency understand this as an argument for the existence of paraconsistent inferences in human thinking (Anderson et al. 2013). However, people in the experiment were actively reinterpreting the meaning of the reply in order to remove contradictions. Not to keep them simultaneously in their belief structures and perform inferences on both. As a result, they understood the reply in the experiment not as: $(p \wedge \neg p)$ but as $(p \wedge q)$. This misunderstanding between psychological works and paraconsistent logicians is even more apparent when considering research on the so-called *cognitive dissonance*.

3.1 Cognitive dissonance

The issue of contradictory information in human thinking is most often tackled by psychologists with the paradigm of *cognitive dissonance*. Cognitive dissonance is a phenomenon where a person becomes aware of an inconsistency

between two or more beliefs that he or she holds. The concept was originally coined by Leon Festinger in his book: *"A Theory of Cognitive Dissonance"* (1957). He argued that experiencing an apparent contradiction causes psychological stress and prompts people to remove it as soon as possible. A typical example of a cognitive dissonance is the conundrum of the cigarette smoker. How come that people who are aware of the adverse effects of smoking and declare that they do not want to prematurely die, still smoke cigarettes? Let us denote the smoker conundrum in the most generous way possible, so that it will involve an actual contradiction of the form: *It is the case that p and ¬p*:

$Premises$:
p : *Smoking cigarettes is not healthy*
q : *I do not want to do any things that are not healthy*
r : *I want to smoke cigarettes*
$Conclusions$:
$p \wedge q \implies \neg r$

As we see, from the set of beliefs that a smoker holds, it might be possible to derive a conclusion that is contradictory to one of the premises ($\neg r$). However, it is important to highlight that the sentence r from the premises (*I want to smoke cigarettes*) was not a part of the inference that led to $\neg r$. A contradiction appears only when the set of original premises is compared to the set of premises enriched by the new conclusions derived from it. The sentence: r and $\neg r$, is not a starting point of any inferences, but an end to them. Moreover, it gives rise to cognitive dissonance, which is a phenomenon aimed at getting rid of that contradiction. In general, researchers have proposed that humans deal with such contradictions in four ways (McGrath 2017):

– By changing one of their beliefs, values or behaviours. It is the most straightforward approach, and for the smoking example this strategy could mean completely abandoning one of the premises. Abandoning any of the original premises: p, q or r, removes the contradiction.
– By justifying one their beliefs via challenging another. The justification process involves adding new premises and modifying some of the old ones (which actually means abandoning them and replacing them with others). For example, if we add new *"justification"* premises: t: *I want to do fun things* and u: *Some fun things are not healthy*, we end up with a new inference that leads to a new contradiction: $t \wedge \neg q$ (and $\neg q$ contradicts the original premise q). As a result, the person abandons q and replaces it with q': *I want to do only some things that are not healthy*. The ultimate result is similar as in the first strategy (the challenged premise is abandoned), but the process has extra steps and a new replacement premise is added.
– The third strategy as described by psychologists involves introducing new beliefs that justify some of the old ones. In the smoking example it could mean introducing a new belief w: Doing healthy things allows doing some of the unhealthy things, which could translate into: *"I can keep smoking if I balance it out by going to the gym twice a week."* From a purely formal

perspective this strategy is akin to the previous one, since some premises are added and some are removed (i.e., the premise q which addresses *"any"* unhealthy behaviours has to be replaced again with a weaker one).

– The fourth strategy of dealing with cognitive dissonance involves denial of the existence of a contradiction, through discarding one of the premises. For example, a smoker could say: *"Smoking is not really unhealthy, it is just propaganda."* Again, from a purely formal perspective this strategy is the same as the first one – one of the premises is abandoned (p: *Smoking cigarettes is not healthy*), hence the contradiction never occurs.

It appears that the essence of dealing with contradictory information is discounting one of the two opposing premises. Psychologists were also interested in identifying which types of premises tend to be discounted most often. They identified two most predominant types of beliefs that people hold. On the one hand there are *conditional beliefs*, which express laws, hypotheses, theories or rules that govern reality. For example: *"If I turn the key, my car's engine will start."* On the other hand there are *categorical beliefs*, which express observed facts, for example: *"It is raining."* Numerous experiments have shown that people have a tendency to reject conditional premises more often than categorical premises (Byrne & Walsh 2005). Most of the time, the rejection is not complete and a modified, weakened premise takes the place of the original one, just like in the aforementioned smoking example, where "not wanting to do *any* unhealthy things" is replaced with "not wanting to do *some* unhealthy things." This is interesting, because it appears that humans are more readily able to revise their convictions about the rules that govern the world rather than revise the content of their own sensual observations of it.

The presented strategies of dealing with cognitive dissonance highlight two crucial facts. First, that contradictions causing the dissonance are not premises for any reasonings, but their conclusions. Second, that as soon as a conclusion appears that is contradictory with our beliefs, we rush in to remove the inconsistency, never allowing it to be a foundation for any reasoning. An argument against such a statement could be made by stating that inconsistencies often already exist within a persons' beliefs for a long time, while the cognitive dissonance appears only after they are made consciously aware of them. Therefore, one could say that before the contradiction was made visible, the person was in fact reasoning from contradictory premises without being aware of it. However, that argument assumes that all the beliefs, values and ideas that we hold form one big set (i.e., a huge and messy set of premises), which is not the case.

Human beliefs, ideas, values and any other concepts that could be reduced down to statements of natural language do not form a singular set and cannot be trivialized to one. One of the most prevalent paradigms in cognitive science deals with the modularity of the human mind and partitions it into several separate *"modules"* which process different types of information and produce different types of outputs (i.e., thoughts, emotions, behaviour, etc.) (Calabretta & Parisi 2009). Human brains are comprised of separate areas

that differ from each other anatomically and specialize in processing specific kinds of signals (e.g., auditory, visual, tactile), making them functionally distinct, even though they communicate and cooperate constantly. Neuroimaging studies already provided substantial amounts of data in support of that view (Purves et al. 2008). From the biological partitioning of the brain stems a view that the human mind (understood as the product of the brain function[10]) can also be analysed as a set of modules. This view is especially useful for evolutionary science, where the mind is compared to a *"Swiss Army knife,"* where every mental system has developed throughout evolution as a result of the environmental demands. This overarching modularity in the brain also translates into more intricate, specific modularity that is immediately relevant for the considerations on human reasoning. Namely, the existence of the so-called *cognitive schemata* or *cognitive scripts.*

The term *cognitive schema* in psychology is very broad and denotes almost any memorized set of information (Derry 1996). In philosophy, cognitive schemata are often understood as *mental representations.* Historically, the theory of cognitive schemata can be traced to the philosophy of Immanuel Kant (Marshall, 1995) and to Gestalt psychology. Because the definition of schema is so broad, it captures many different types of information as different kids of schemata, for example: beliefs, stereotypes, social roles, etc. The crucial point is that to conserve energy and to maximize efficiency, not all schemata are "active" at the same time when humans think. Depending on the environment, only the relevant schemata are going to be "active" and used in inferences (or in regulating behaviour and emotions). For example, students in the mathematics class will have their schemata containing mathematical laws active, making their work on the exercises faster and more accurate. At the same time, if the same students were to be asked about some formula during a social gathering, it would take them a few moments to retrieve the schema and remember the answer. From an evolutionary perspective it would be a waste of valuable resources to use all available information in all circumstances, instead of using only the information judged as relevant.

For the purposes of analysing the logic of human thinking, cognitive schemata can be understood as sets of premises from which conclusions (i.e., behaviour) can be derived[11]. As a result, different schema may contain different premises, which could sometimes contradict each other if brought together. The contradictions would remain unknown, for as long as two inconsistent schemata are not used together for the purposes of some reasoning. However, if that happens, cognitive dissonance occurs and the contradiction has to be removed. That means that people do live with contradictions, but do not reason from them. Contradictions are spread across separate *schemata/mental representations/memories/cognitive scripts* and do not form a uniform, inconsistent set

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[10] A common view of neuroscientists and psychologists on the nature of the mind is summed up in the quote by Swaab (2014, page 5): "The product of the interaction of all these billions of neurons is called 'mind'. Just as kidneys produce urine, the brain produces mind (...)"

[11] Of course, linguistic premises alone would not be sufficient to explain human behaviour as they would not properly represent e.g. emotions.

of premises. Furthermore, even human reasoning abilities are partitioned, so that different types of inferences are performed by different mental modules localized in different parts of the brain (Osherson et al. 1998, Wertheim & Ragni 2020). In fact, even the process of resolving contradictions itself has been isolated and pin-pointed to specific brain regions (Medaglia et al. 2009, Porcaro et al. 2014). This concept of partitioning of the self is not foreign to philosophy. Ruwen Ogien, French philosopher wrote: *"There is no hardcore personality, stable, unified, invariant from one situation to another"* (Ogien 2011, p. 40, translation by: Berliner et al. 2016)

However, a question may be asked: why do people refuse to reason from inconsistent premises? It is false to say that such reasonings are completely impossible, because paraconsistent logics clearly show that it is possible to devise a system that tolerates some inconsistencies. As before, the answer lies in the evolution and the efficiency of our cognition. In his works, Leon Festinger did not explain why do people experience cognitive dissonance or what is the purpose of its existence (Harmon-Jones & Harmon-Jones 2007). The simplest answer is that cognitive dissonance causes mental stress, negative affect or discomfort and people seek to remove these feelings (Newby-Clark et al. 2002). However, that does not explain anything, since we can continue to ask: why does a contradiction cause stress?

A compelling answer that ties to logic and information theory was recently given by Kaaronen (2018). The author relates cognitive dissonance to the fact that the human mind is constantly engaged in a phenomenon called *"predictive coding."* Predictive processing is a theory stating that the human brain continuously attempts to anticipate the incoming stimuli (i.e., information). To put it simply, a stimuli successfully predicted before it arrived, is a stimuli expected, probably safe and most probably well-understood. Conversely, something unexpected is potentially dangerous and because a schema for an unexpected stimulus could not have been activated in advance, it takes more effort (i.e., resources) to comprehend. As a result, the theory of predictive processing postulates that humans aim to reduce *"prediction error,"* which means instances in which the anticipations of the brain failed to successfully meet the incoming information. Kaaronen (2018) points out that contradictory information is useless in minimizing the prediction error. It is even worse that no information at all, since contradictory information takes up resources to be encoded, while providing no advantage in predictive processing at all. As a result, humans aim to remove contradictions, to avoid prediction errors and unnecessary use of resources, which could both translate into maladaptive behaviours.

Overall, the aspects of the cognitive dissonance most important for logic are:

– Contradictions that cause cognitive dissonance are not premises for inferences, but their conclusions.

- Contradictory information is held by people, but in separate sets of premises (i.e. cognitive schemata) and cognitive dissonance occurs when different sets of premises are merged into a new, inconsistent one.
- The very nature of cognitive dissonance is to remove these contradictions as soon as they are detected.
- Holding contradictory information in separate cognitive schemata may be useful (different circumstances require different approaches), but a contradiction held in the currently active set of premises impedes predictive coding.

3.2 Dialectical thinking

The other way in which psychology addresses the existence of contradictions in human thinking is the so-called *"dialectical thinking."* Dialectical thinking may be considered an opposite of the cognitive dissonance. Peng & Nisbett (1999, p. 4) defined it as: *"cognitive tendency toward acceptance of contradiction."* The proponents of that concept ascribe it in particular to the Chinese culture and philosophy. They explain, that Western culture was built on the foundation of Aristotelian logic, especially the laws of non-contradiction and the law of excluded middle, often separating the form from the content (i.e., syntactic from semantic). In contrast, East Asian philosophy focused on the ideas of change, holism and the integration of the form and the content. As a result, dialectical thinking is supposed to be more prevalent among the members of the Eastern cultures who are seemingly more tolerant towards contradictions. Dialectical thinking is therefore considered to be a personality trait and empirical psychological studies pursue answers to how "tolerance of contradictions" affects our reasoning and behaviour (DeMotta et al., 2016).

However, a closer inspection of the concept of dialectical thinking reveals a fatal flaw in its definition and conceptualization. To uncover that flaw, let us consider the extensive theoretical explanation of dialectical thinking provided by Peng & Nisbett (1999)[12]. The authors explicitly contrast dialectical thinking with the thinking that satisfies the law of non-contradiction and the law of excluded middle. They write:

> *"It is obvious now to readers that these laws of formal logic are not congruent with the principles of Eastern naïve dialecticism. (. . .) Hence, for a dialectical thinker, both A and B may be right, or both A and B[13] may equal a third element C that may not be part of the initial contradiction."*

Thus, we would expect that dialectical thinking defined in this way would be close to paraconsistent logics, where a truly inconsistent set of premises may

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[12] I picked that work since its authors are arguably the most notable researchers of dialectical thinking and their works on the matter have been extensively cited. For more literature on the issue see also: Nisbett et al. (2001), Spencer-Rogers et al. (2009), DeMotta et al. (2016), Wong (2006).

[13] By B the authors most probably mean $\neg A$.

yield meaningful conclusions, instead of exploding. However, a closer look at the principles of dialectical thinking and the examples given by the authors paints a whole different picture. Peng & Nisbett (1999) define the original principles that are supposed to be in contrast with the Aristotelian tradition and gave rise to dialectical thinking as follows:

– Principle of change (*Bian Yi Lu*) states that everything is a process, everything is subject to constant dynamic changes and everything flows from non-existence into existence and vice-versa.
– Principle of contradiction (*Mao Dun Lu*) states that reality is filled with contradictions (e.g. good and evil, old and new). An example of that principle in the old Daosim is given by Lao-zi (570?-490?BC/1993, p.16): *"When the people of the world all know beauty as beauty, there arises the recognition of ugliness; When they all know the good as good, there arises the recognition of evil. And so, being and nonbeing produce each other."*
– Principle of holism (*Zheng He Lu*) states that everything is connected and that to understand a concept fully it has to be understood in the complete context of its existence and its relations to other concepts. Everything analysed in separation from the rest will be distorted and the whole is more than just a sum of its parts.

These three principles are meant to constitute foundation for a mode of thinking, where contradictions are tolerated or even welcome. However, so far, nothing in these principles explicitly violates the laws of non-contradiction and the law of excluded middle. In the first principle, constant changes are thought to be a source of contradiction because they were summed up with a metaphor: *"life is a constant passing from one stage of being to another, so that to be is not to be, and not to be is to be"*(Peng & Nisbett, 1999, p. 7). However, highlighting the fact that reality is a process and is dynamically changing does not have to imply any contradictions of the conservative form: It is the case that p and $\neg p$. A metaphor that states *"to be is not to be, and not to be is to be"* is useful to understand the general message and spirit of the principle, but does not express the actual content of the *Bian Yi Lu* principle that was otherwise stated. One could not use that metaphor alone and infer the content of the principle from it without extensive additional information. Interpreting metaphors that contain contradictions cannot be equated with accepting contradictions in reasoning, because the process of interpreting is one of ascribing a meaning to a statement – a meaning that ultimately will not contain a contradiction – just like in the aforementioned principle. However, the proponents of dialetheism would strongly disagree with that interpretation and argue that the eastern philosophy should be often taken literally and not as metaphors (Deguchi et al. 2008).

For the other two principles, the postulated incompatibility with the law of non-contradiction and the law of excluded middle is even less apparent. The principle of contradiction merely states that opposites exist in the world at the same time. It is not contradictory to say that beautiful things exist at the same time as ugly things exist. It would not even be contradictory to

say that something could be beautiful and ugly at the same time, because the existence of two independent, subjective judges of beauty is implied. Nothing in the second principle, nor in the third postulates that sometimes it is the case that p and $\neg p$.

It appears that proponents of human dialectical thinking do not define it as thinking from contradictory premises in the strict sense of the term. Indeed, in their first example, Peng & Nisbett (1999, p. 1) present two statements that are supposed to contradict each other:

> "A: Two mathematicians have discovered that the activities of a butterfly in Beijing, China, noticeably affect the temperature in the San Francisco Bay Area.
> B: Two meteorologists have found that the activities of a local butterfly in the San Francisco Bay Area have nothing to do with temperature changes in the same San Francisco Bay Area."

The authors go as far as to write that saying that these two statements do not contain a contradiction is *"pretending"* and a strategy of *"denial"*. However, even though these two statements are unlikely to be both true, they are definitely not contradictory in the strict sense. Therefore, it appears that dialectical thinking is a phenomenon of tolerance for "weak" contradictions or *quasi-contradictions* – statements that are unlikely to be both true at the same time, metaphors that use contradictions, opposite but co-existing concepts (e.g. ugliness and beauty). This fact was already pointed out by Chan (2000) in his article, the title of which says it all: *"Formal logic and dialectical thinking are not incongruent."* I move one step further than that and highlight, that true contradictions are extremely rare in human thinking and that postulating that humans tolerate inconsistency in their reasoning is suspicious at best.

4 Discussion

Human history and literature is overflowing with instances of apparent contradictions. In the beginning of twentieth century, anthropologists debated if the law of non-contradiction is a universal rule across cultures. Lucien Lévy-Bruhl (1910) postulated that it is culture-specific. He cited Indians from South America who had no problem with saying, for example: *"We are red parrots"* or *"Sorcerers are bush cats."* He later changed his mind and returned to considering the law of con-contradiction as universal. However, the idea that many cultural works are examples of contradictions survived. Hegelian and Marxist dialectics are often cited as a primary example of them, even though upon closer inspection, there is no inconsistency to be found anywhere in those theories. They propose that thesis and anti-thesis are opposing forces that interact to produce a synthesis. But thesis and anti-thesis are separate phenomena. Nothing in dialectics is supposed to be simultaneously true and false, instead it is merely the opposition between mutually exclusive ideas. In Table 1, I

Table 1 Examples of quasi-contradictions used in the literature to show that humans tolerate contradictory premises.

Type of the quasi-contradiction	Examples
Statements that are unlikely to both be true or conditional statements with missing context	– Everything we eat causes and prevents cancer at the same time – Some researchers verified theory X and some researchers falsified theory X
Metaphors and oxymorons	– "to be is not to be, and not to be is to be" – "I must be cruel only to be kind"
Co-existence of opposite ideas	– Freudian "splitting of the ego" (co-existence of fear and desire for castration) – Carl Jung's idea of "self" as coincidentia oppositorum (anima and animus, persona and shadow) – Hegelian dialectics (co-existence of thesis and antithesis) – Chinese dualism (yin yang)
Behaviours incongruent with some personality trait	– Being both superstitious and Christian – Smoking and caring about own health

summarize some typical examples of using the word "contradiction" in a common sense to describe things that are not contradictions in the logical sense of the word.

David Berliner (2016, p. 2) in his anthropological study of contradictions in the human culture wrote:

"Yes, humans are full of contradictions. So, how to live with principles, emotions, and behaviours that contradict each other? How can one have a thought, and in the same movement, its opposite?"

This critical question contains the clue to solving the problem of contradictions in human reasoning. It is the fragment that reads: *"in the same movement."* The research on human reasoning under the conditions of inconsistency taught us that humans as a whole can indeed entertain contradictory premises throughout their lives. At one time we can choose to believe p, but on another time when the context is different, we can believe $\neg p$. However, no study so far

showed any indication that humans can simultaneously accept p and $\neg p$ and derive non-trivial conclusions from both at the same time. The emphasis on the timeframe is critical for unravelling how humans process inconsistencies.

The Aristotelian psychological principle of non-contradiction translated by Łukasiewicz states that contradictions *"cannot obtain in the same consciousness."* Unfortunately, empirical research clearly shows that this formulation of the principle cannot hold. Clearly, spread across different points in time contradictory beliefs can exist within the consciousness of a person. Łukasiewicz formulated his interpretation of the law of non-contradiction long before psychology became an established field of science and gave any insights about human consciousness. As a result, his formulation of the principle was the best for its time. However, according to our current (albeit very limited) understanding of the human mind, consciousness is a process, not a physical object. Speaking of the existence of contradictions within a consciousness calls for specifying a timeframe. Same goes for our memory, self, beliefs or schemata. Does it qualify our reasonings as paraconsistent if on Monday we believe p and on Sunday we begin to believe $\neg p$? It appears that the relevant timeframe should be defined by behaviour. I defined beliefs as the information that is being used in decision making. As a result, beliefs are the information that was processed by the brain and resulted in a given decision/behaviour. This is a physicalist, reductionist and in-fact very deterministic definition of beliefs. However, that definition is good bridge between the empirical domain of psychology and the formal domain of logic.

Interestingly, the un-adapted, original formulation of the non-contradiction principle by Aristotle better suits that reductionist view of beliefs: *"No one can believe that the same thing is and is not."* If believing is defined as the information that leads to a singular behaviour, then the law of non-contradiction is not violated. The studies on cognitive dissonance and predictive coding described in this article demonstrated that humans persistently refuse to accept two contradictory premises in a given situation and always reject or modify one of them.

Of course, our current understanding of human beliefs is largely dependent on introspection (i.e., self-report). Not only do we as researchers have no access to the internal world of a research subject, every human has limited access even to their own mental processes. Every reply to a question in an experiment goes through the filter of consciousness and is subjected to the limitations of language. However, thanks to the recent scientific advancements in measuring brain activity with neuroimaging it might be possible to analyse human beliefs without having to resort to explicitly asking research participants for their opinions. Instead, we can refer to the unconscious mechanisms of information processing and create correlates (i.e., biomarkers) that can be viewed as epiphenomena to mental processes (i.e., qualia). For example, with the use of such methods it was recently demonstrated that the Liar paradox is processed by the human brain like a false statement (Rudnicki & Łukowski, 2019). Future studies could empirically address the question if it is indeed truly impossible to believe contradictory statements. Of course, such studies

would still not give us full access to the mental processes of another person, but at least they rid us of the additional problems with introspection and communicating thoughts with language.

To the best of my knowledge, any existing empirical research in cognitive science, that deals with processing of contradictory information, implicitly assumes that the law of non-contradiction has to be satisfied and that humans *"update their beliefs"* by using new information to determine which of the two is more likely to be true: p or $\neg p$ (Kalra et al. 2011). In fact, the process of belief updating is critical for learning since the presence of contradictions prompts humans to explore the environment and search for a solution of the contradiction (i.e. obtain information that would allow to abandon one of the contradictory premises). More than that, by causing confusion, contradictions can even facilitate the learning process (Lehman et al. 2011). A beautiful example of seemingly co-existing contradictory beliefs, which are not really contradictory upon closer inspection, was given by Wood et al. (2012). The authors examined peoples' degrees of belief in different mutually-exclusive conspiracy theories. Participants in their study had to rate on a 7-point scale how much do they agree with several statements. The most notable examples were (Wood et al. 2012, p. 769-770):

1. *One or more rogue "cells" in the British secret service constructed and carried out a plot to kill Diana*
2. *Diana faked her own death so that she and Dodi could retreat into isolation.*
3. *Osama bin Laden is still alive.*
4. *When the raid took place, Osama bin Laden was already dead.*

The results showed that belief in any conspiracy theory was positively correlated with beliefs in other theories, even if they were contradictory. In other words, if a person indicated that they believe that the British Intelligence assassinated Diana, then statistically speaking, they were also more likely to to indicate that they believe that Diana is still alive and faked her own death. Identical relationship was found for statements regarding Osama bin Laden. At a first glance, this is clearly a situation when some people just simultaneously believe in completely opposite premises. An argument against it could be made by pointing out the probabilistic nature of answers given by participants (1-7 scale). However, an even better argument was inadvertently by the authors of the study themselves. To analyse what makes people believe in statements about Osama bin Laden, they also asked the participants if they agree with the statement (Wood et al. 2012, p. 770):

5. *The actions of the Obama administration indicate that they are hiding some important or damaging piece of information about the raid*

Not surprisingly, the degree of agreement with that statement was positively related to degrees of agreement with statements 3 and 4. In other words, people who indicated that they believe that the government is hiding something were also more likely to indicate that they believe both that Osama bin Laden is alive and that he was already long dead before the raid. However,

most importantly, statistical analysis showed that the positive correlation between statements 3 and 4 completely disappears when statement 5 is entered into the equation. In simple words, people who indicated belief in contradictory theories, did so not because they specifically believed them both at the same time. They did so because they believed that the government was involved in some kind of a cover up, but they just did not know which one. The authors summarize it as follows (Wood et al. 2012, p. 771):

> "This indicates that the correlation in endorsement of the two contradictory theories is explainable entirely by their connection with belief in a deceptive cover-up by authority (...) For those who hold such beliefs, the specifics of a conspiracy theory do not matter as much as the fact that it is a conspiracy theory at all."

Psychological literature does not argue with the fact that people could have contradictory beliefs. However, it points out that these beliefs are stored separately in different sets of beliefs and whenever we need to merge these sets for some reasoning, a cognitive dissonance appears to get rid of the contradiction. This view is supported by the research on the modularity of the human mind, but not only that. Anthropologists have been aware of that phenomenon long before cognitive psychologists began their work on it. In 1955, when behaviourism reigned supreme in psychology and rejected any notions that pertained to the mind, anthropologist Roger Bastide proposed something called: "the compartmentalization principle" to explain the co-existence of contradictory behaviours in Afro-Brazilian rituals (Bastide 1955). He argues that human actions have to be always considered in context. In different circumstances, different beliefs take precedence. For example, people who participate in the occult, while at the same time being members of the rational world, "distinguish between domains of truth that 'belong to different dimensions'" (Berliner et al. 2016, p. 3). The compartmentalization principle can be expressed in even simpler terms. Anthropologist Richard Schweder gives an example stating: "The entire top of the table appears to be green and the entire top of the table appears to be grey" (Berliner et al. 2016, p. 10). He points out that nobody would consider this a violation of the non-contradiction principle, because visual and tactile perception are separate *compartments*. The same goes for other cognitive structures of the human mind, like schemata, memories, etc. Modern cognitive psychology supports this view and no longer considers the human *self* to be a unified entity.

Interestingly, modularity of the mind and the compartmentalization principle are known to some paraconsistent logicians. McGinnis (2013, p. 639) in his work devoted to explaining how paraconsistent logic can be applied to explain the existence of inconsistencies in natural language wrote:

> "Any serious scientific theory of natural language must take into account the fact that modularity of mind will lead to ineliminable informational inconsistencies. What is far less obvious, and a harder problem for future research, is what exact form this inconsistency-tolerance takes."

However, he takes it as an argument for the paraconsistency of human everyday thinking, not against it, McGinnis (2013, p. 631):

> *"It is a simple fact of psychology that our internal mental states can conflict in fundamental ways, with each other and with themselves. Any theory of mind that is committed to the existence of real mental events is ipso facto committed to inconsistency, as is any theory of language that concerns itself with internal (mental) events as well."*

Here we argue that modularity of the mind does not lead to inconsistencies but instead is actually a form of inconsistency removal.

In conclusion, humans the masters of contradicting themselves. We hold contradictory beliefs and create countless ideas that seem inconsistent. Trying to model our thinking with classical logic has proven to be difficult, if not impossible. However, despite that, whenever we perform an inference that leads to any particular behaviour, we do not tolerate contradictions. We defend ourselves from them with the various mechanisms of cognitive dissonance and compartmentalization. Where paraconsistent logics start their inferences, humans end theirs.

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