

SYNAESTHETIC TENDENCIES IN CHIMPANZEES (PAN TROGLODYTES) as evolutionary advantages and learning aids, as compared to the human synaesthetic spectrum

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Abstract: The present paper investigates how and to what extent synaesthetic tendencies, namely, the visuoauditory mappings between high luminance and high pitch (Ludwig, Adachi, Matsuzawa 2011) and structural isomorphisms across sensory modalities (Ravignani, Sonnweber 2017) discovered in chimpanzees (Pan Troglodytes), can be explained in terms of evolutionary advantages and learning aids. This approach sheds new light on the interpretation of existing cross-modal capacities in chimpanzees, and suggests novel similarities between human and chimpanzee cognition.

This paper introduces synaesthesia and the synaesthetic spectrum, with special emphasis on the nature of audio-visual cross-modal mappings, followed by insights into chimpanzee umwelt. Subsequently, theories about the possible evolutionary benefits of the condition are analysed, arriving at implications about human vs non-human primate cross-modal meaning-making. Results suggest that chimpanzees are capable of all three cross-modal processing forms found in nature: discreet mapping, continuous mapping and cross-modal isomorphisms. These capabilities can broadly be characterised as synaesthetic tendencies and have equivalents in human multi-modal perception. While the existence of vivid synaesthesias in chimpanzees cannot be ruled out, the observed synaesthetic phenomena in chimpanzees are comparable to the cross-modal capacities of pre-teen human children. In this regard, language and culture appear not essential for cross-modal abstract mapping. Therefore, synaesthetic tendencies can be seen as basic, primary sensory processing mechanisms for primates that are evolutionarily earlier than human linguistic abilities. In this case, it can be suggested that synaesthetic phenomena might play an even bigger role in chimpanzee umwelt than human umwelt. As the existing research on this topic is scarce, further directions of exploration might include testing chimpanzees for other kinds of synaesthetic phenomena, and investigating the role of learning human abstract concepts on the ape's synaesthetic experiences.

Keywords: synaesthesia, cross-modal processing, chimpanzee cognition, umwelt

Sünesteetilised tendentsid šimpansites (*Pan troglodytes*) kui evolutsioonilised eelised ja abivahend õppimisel, võrrelduna inimeste sünesteetilise spektrumiga

Abstrakt: Käesolev artikkel uurib, kuidas ja mis määral võib sünesteetilisi kalduvusi, mida on avastatud šimpansitel (*Pan troglodytes*) selgitada evolutsiooniliste eelistena ja abivahenditena õppimisel. Sünesteesia vormid, mis käsitlust leiavad on visuaal-auditoorsed vastavused valgustugevuse ja helikõrguse vahel (Ludwig, Adachi, Matsuzawa 2011) ning struktuuralsed isomorfismid tajumodaalsuse vahel (Ravignani, Sonnweber 2017). Siinne käsitlus näidab šimpansite ristmodaalsete võimete tõlgendamisvõimalusi ja pakub uusi sarnasusi inimeste ning šimpansite tunnetustes. Artikkel tutvustab sünesteetisat ning sünesteetilist spektrumi, keskendudes eriti audiovisuaal-ristkaardistustele, millele järgneb sissevaade šimpansi maailma. Järgnevalt analüüsitakse teooriaid, mis käsitlevad konditsiooni võimalikke evolutsioonilisi eeliseid ning jõutakse järeldusteni inimeste ning teiste primaatide ristmodaalse tähendusloome kohta. Tulemused vihjavad sellele, et šimpansid on võimelised kõigiks kolmest ristmodaalsetest töötlustest, mida looduses leidub: diskreetseks kaardistuseks, kontinuaalseks kaardistuseks ning ristmodaalseteks isomorfismideks. Neid võimekusi võib üldistavalt käsitleda kui sünesteetilisi kalduvusi ning neil on ekvivalente inimeste multimodaalses tajuvõimes. Kuigi ei saa välistada, et šimpansite seas võib leiduda ehedaid sünesteete, on seni täheldatud sünesteetilised fenomenid võrreldavad eelpuberteedialiste inimeste ristmodaalse võimekustega. Sellega seoses ei näi keel ning kultuur olevat olemuslikud abstraktse ristmodaalse kaardistuse jaoks. Seega võib sünesteetilisi tendentse näha primaarsete tajumehhanismidena primaatide jaoks, kellel puudub keelevõime. Antud juhul võib pakkuda, et sünesteetilised nähtused pakuvad isegi suuremat rolli šimpansite maailmas võrreldes inimeste omaga. Kuivõrd olemasolevaid uurimusi sellel teemal on vähe, võiks edasised uurimused kaasata katseid šimpansitega, et tuvastada teisigi sünesteetilisi nähtusi ning uurida, kuidas mõjutab abstraktsete mõistete õppimine primaatide sünesteetilisi kogemusi.

Märksõnad: sünesteesia, ristmodaalne töötlemine, heli tajumine, šimpansite kognitsioon, maailm

1. Synaesthesia and synaesthetic tendencies: Short overview

Having existed, as will be suggested later in this paper, even before the dawn of the human race, in its most widespread sense, the neurobiological condition of synaesthesia can be defined as “anomalous perceptual experiences that are triggered by activity in another sensory modality (e.g. sounds triggering colours or touch invoking taste) or by cognitive activity (e.g. numbers inducing colours or emotions provoking experience of taste)” (Ward et al. 2008: 128). The condition affects roughly 4% of the general human population, providing for highly altered conscious and unconscious meaning-making processes resulting

in highly persistent, involuntary and idiosyncratic experiences whereby a certain stimulus (often referred to as “inducer”) produces a concurrent-specific sensory perception (in synaesthetes-projectors) or association (in synaesthetes-associators) (Bargary, Mithcell 2008: 335-336).

Up until the 19th century, documented cases of manifestations of synaesthetic phenomena were scarce and of discussable authenticity (see accounts by Locke, Rondet, Bertrand-Castel, Hoffmann in Jewanski, Day, Ward 2009: 295-296, Baumgarten, Kant in Van Campen 2009:3). The rise of synaesthesia research from the 19th century onwards has been closely linked to advances in psychology during that time, cognitive science research of the 20th century, as well as the medical and technological advances of the 21st century allowing an in-depth study of synaesthetic meaning-making processes in the human brain. However, up until the beginning of the 21st century, scientific thought had not paid interest to possible synaesthetic phenomena in non-human species.

One of the most prominent features of synaesthesia is its multi-faceted nature that makes it an adventurous field of research for a variety of disciplines, among others, psychology, neuroscience, cognitive sciences, linguistics and semiotics, at the same time, leaving a lot to question. Currently, more than 73 types of synaesthesia have been documented (Day 2005), with an overwhelming prevalence of visual synaesthesias. Apart from the vast array of types, the highly idiosyncratic nature of the condition results in each affected individual exhibiting very individualistic and specific inducer-concurrent relations, resulting in something similar to a personal synaesthetic “code” (even within the same synaesthesia type, different individuals have different concurrents for the same inducer).

Neuroscientists tend to limit the scope of synaesthesia proper to the above-explained phenomena, which Marks (2011) denominates as vivid synaesthesia. However, several cross-sensory correspondences and similarities are perceived by the general human population almost universally, as exemplified by the tendency to link higher frequencies with greater luminosity and lower sounds to darker colours, resulting in correspondence between sound pitch and visual lightness/ darkness; louder sounds to brighter colours, higher pitches to smaller images, higher pitches to sharper angles, which establish linkages similar to those of vivid synaesthesia. The existence of widespread perceptual similarities, denominated by Marks’ synaesthetic tendencies, as opposed to vivid synaesthesia, allows talking about synaesthetic phenomena as a spectrum (“perceptual-behavioural continuum” (Marks 2011)), ranging from least synaesthetic (cross-modal metaphor, cross-modal similarity) to most synaesthetic (induced imagery or experience). This view corresponds to synaesthetic monism (Marks 2011: 67-68), which seeks to provide the most inclusive and fluid approach to the synaesthetic phenomena, and is of special interest in the light of existing findings about the perception of audio-visual

cross-modal similarities and detection of cross-modal isomorphisms in chimpanzees, that could be broadly characterised as synaesthetic tendencies (Marks 2011: 52-53).

Among researchers sharing the stance of monism, Hunt (2005; 2011) views adult (vivid) synaesthesias as primarily based on childhood physiognomic associations. The importance of these associations usually declines around the early teenage years, as these “felt meanings” are internalised as full metaphoric understanding/ use. Similarly, Ramachandran and Hubbard (2001) propose that synaesthesia-like processes might have served as the initial impetus for human proto-language origins and its evolution, as language origins can be traced to a cluster of phylogenetically earlier cross-modal mechanisms exaptated for other means. This way, synaesthesia can be regarded as a tool for studying metaphor and creativity since metaphor implies the cross-activation of conceptual maps in a similar way as the cross-activation of perceptual maps or the link between conceptual and perceptual maps in synaesthesia.

Vivid synaesthesia and synaesthetic tendencies, while sharing several characteristics, differ phenomenologically. Vivid synaesthetic experiences, as briefly introduced above, are highly persistent, involuntary and idiosyncratic, as well as absolute (inducer-concurrent relationships are persistent and specific), and rigid (invariable over time), whereas synaesthetic tendencies are much more relativistic and context-dependent (such as linking the brightest colour to the highest pitch or vice versa), as well as flexible. Whether the difference between synaesthetic tendencies and vivid synaesthesia is of quantitative or qualitative nature is still under discussion. However, the abundant prevalence of perceptual and cognitive tendencies in non-synaesthetes allows suggesting that the basis of the sensory processing mechanisms of synaesthesia might be shared between synaesthetes and non-synaesthetes alike and that sensory processes might have a leading role in cognitive processing, not just a supporting one (Marks 2011: 53-59). The similarity of these sensory processing mechanisms allows the synaesthetic spectrum of synaesthetic monism to include both vividly synaesthetic persons, a large part of the general human population experiencing synaesthetic tendencies, as well as non-human individuals (chimpanzees) experiencing at least some part of the synaesthetic spectrum. Before proceeding to further analyse the nature and implications of synaesthetic phenomena detected in chimpanzees, it has to be emphasised that the overwhelmingly audio-visual character of synaesthetic tendencies in humans, and, as will be elaborated upon later in this paper, in chimpanzees, is in congruence with the historical and modern-day demographic data about the prevalence of different vivid synaesthesia types. Visual and colour-type vivid synaesthesias abound overwhelmingly: 18,5% of synaesthetes report experiences of coloured musical sounds, 14,3% perceive coloured general sounds, and 10,8% see coloured musical notes (Day 2005: 15). These data about vivid synaesthesias, along with the structure of synaesthetic metaphor in language and synaesthetic tendencies

exhibit the same trend for following a certain “lower-to-higher” hierarchy of mapping one sensory domain onto another: from touch as the “lower” sense to taste, smell, sound and sight as the “higher” sense. Shen and Aisenman (2008: 108) suggest this is a universal preference in natural language. In this way, for example, “red melody” is a more widely experienced synaesthetic link than “melodic redness”. In this regard, in the light of synaesthetic monism, it can be suggested that the mappings from least to most synaesthetic phenomena generally exhibit very similar structures both above and below the linguistic threshold and have similar prevalence – another point in favour of viewing them as a continuum, rather than separate phenomena.

2. Chimpanzees: Umwelt of and cross-modal processing

Generally, chimpanzees (*Pan Troglodytes*), being human’s closest relatives¹, are thought to share several commonalities with humans regarding colour perception and categorisation, independently of a human’s or chimpanzee’s previous colour categorisation training (Matsuno, Nobuyuki, Tetsuro 2004). This is largely due to chimpanzees possessing trichromatic colour vision, just like humans do. However, chimpanzees tend to exhibit greater superiority in processing local over global features in response to hierarchical stimulus, whereas humans as young as a few months old are more capable of perceiving the global level of such stimuli (Imura, Tomonaga 2013). Moreover, studies show that the visual world is perceived quite similarly by such species as humans, chimpanzees, and dolphins, despite the variable dependency on vision and adaptation to different environments (Tomonaga, Uwano, Saito, 2014). Additionally, research shows that chimpanzees, just like some other animals, have clear colour preferences, with more attention given to blue and green stimuli (with no observable preference among them) than red, preferences that are comparable to those observed in humans, suggesting that such colour preferences might be a result of evolutionary predispositions, despite red being supposedly biologically more relevant. These findings could suggest an innate relationship between the colour and the psychological reaction it invokes in the individual (Wells, McDonald, Ringland, 2008). Interestingly, psychological states such as moods (both clinical mood disorders, such as anxiety and depression, and non-clinical negative moods) have been proven to also influence the

¹ Chimpanzees are the closest relatives alongside bonobos (*Pan paniscus*) to humans. To this day, research on the cross-modal abilities of bonobos is very scarce and does not allow a full assessment of the whole spectrum of cross-modal processing. For reference, see Margiotoudi et al. 2022.

synaesthetic perception of colour, with induced colours becoming less luminescent and/or saturated (Kay, Carmichael, Ruffell, Simner 2014: 487).

Cross-modal processing in different types exists across the animal world. In this regard, Ravignani and Sonnweber (2017) establish three forms: discreet mapping, continuous mapping and cross-modal isomorphisms. Discreet mapping establishes a link between concrete units of different modalities, such as mapping species' mates' faces to their voices in monkeys, chimpanzees, dogs, and horses. In turn, continuous mapping supposes a cross-modal linkage between graded percepts (such as the spontaneous mapping between louder sound and greater luminescence in human infants). Finally, cross-modal isomorphisms require the individual to recognise the similarity in structural characteristics across two or more modalities. Such a cognitive task requires the combination of discrete and structural traits, which may include continuous elements as well (for example, processing the analogy between a patterned string of letters and a musical sequence of an isomorphic structure) (Ravignani, Sonnweber 2017: 74-75). While the first type of cross-modal processing, discreet mapping, has been proven to exist in both humans and some non-human species alike, continuous mapping and processing of cross-modal isomorphisms, which could be likened to synaesthetic tendencies, have lacked documented evidence in non-human species. Such lack of research could be partially explained by the assumption that such higher-level cross-modal abilities require linguistic abilities or cultural predisposition, which are seemingly unique human traits.

In this regard, of special interest are the findings by Ludwig, Adachi and Matsuzawa (2011), Ravignani, and Sonnweber (2017). Ludwig, Adachi and Matsuzawa (2011) have shed new light on the evolutionary roots of synaesthetic tendencies by discovering that they are indeed shared by humans and their closest primate relatives, chimpanzees. It had been previously noted that some chimpanzees, with varying levels of difficulty, are capable of identifying both amodal (for example, voice to conspecific face) and arbitrary cross-modal (for example, sound to individual/object producing it) links (corresponding to discreet mappings).

The previously unknown existence of continuous cross-modal mapping tendencies in chimpanzees with no previous training was detected by giving several individuals a task to classify stimuli as black or white while hearing either high- or low-pitched background sound. As a result, it was found that the chimpanzees' performance was significantly affected by a "wrong" background sound (low-pitched sound for white stimuli and vice versa) (Ludwig, Adachi, Matsuzawa, 2011).

In similar regard, in 2017, Ravignani and Sonnweber added to the discussion concerning the third kind of cross-modal processing, cross-modal isomorphisms, by proving that chimpanzees, not only humans, being previously trained to choose symmetrical structures, are capable of processing and spontaneously detecting structural isomorphisms across visual and auditory

modalities. Suggesting, “basic cross-modal abstraction capacities transcend linguistic abilities and might involve evolutionary ancient neural mechanisms” (Ravignani, Sonnweber, 2017: 74). The discovery of synaesthetic tendencies in chimpanzees is fascinating not only as a finding that places what was thought of as a rare human ability in non-humans but also in the way that these discoveries can shed new light on the evolutionary perspective of human language and abstract thought development. Synaesthetic tendencies in perception are widely observed in human children at an even higher rate than among adults. Children as young as four years old readily establish links between pitch and loudness, as well as loudness and brightness, and pre-teens from 11 years old perceive links between pitch and size (Marks 2011: 58). Some reports even trace synaesthetic perception to infants as young as a few months old, clearly allowing to discuss the relationship between cross-modal abstract concept mapping, learning and origins of the human verbal language, since it becomes obvious that linguistic abilities are not the prerequisite for synaesthetic perception, but probably rather vice versa. The early onset of synaesthetic tendencies in perception implies that they might be innate, hard-wired into human brains, suggesting, in the framework of synaesthetic monism, that, at least partially, similar neural coding mechanisms are responsible for both synaesthetic tendencies and vivid synaesthesias (Marks 2011: 55), as will be discussed in more detail further in this paper.

3. Evolutionary and learning advantages of synaesthesia: Discussion

Contemporarily, many hypotheses regarding the possible origins and functioning mechanisms of vivid synaesthesias have been put forward. Among them, most researchers agree on the hereditary aspect of the condition (Brang, Ramachandran 2011: 1), changes in brain structure and differences in cortical connectivity of synaesthetes, improved connectivity or hyperconnectivity between adjacent or nearby sensory brain regions caused by defective brain pruning in childhood, anatomical differences in the inferior temporal lobe, elevated amount of white matter and grey matter volume (see Anaki, Henik 2017: 143-144; Brang, Ramachandran 2011: 1). Regarding specifically the sound-colour synaesthesia, similar tendencies of which have been found in chimpanzees, research suggests that humans who see sound in colour have enhanced structural (white matter) connectivity, as well as significantly greater white matter integrity in the right inferior frontal-occipital fasciculus of the brain (Zamm, Schlaug, Eagleman, Loui 2013: 359).

Some of the most recent hypotheses involve suggestions that synaesthesia might “serve as cognitive and perceptual anchor to aid in the

detection, processing and retention of critical stimuli in the world [...]” (Brang, Ramachandran 2011: 3). Synaesthesia could also be a “leftover” from associations formed in childhood when the child tries to make sense of abstract concepts by associating them with concrete characteristics (such as colour) (Letalleur-Sommer 2015: 30), or even serve as an impetus for verbal language evolution in ancient times and human metaphorical and symbolic capacity (see Ramachandran; Hubbart 2001:20-21; Hunt 2005: 40- 41). A “middle way” theory between genetics and learning also exists too. Rouw, Schölte, and Colizoli (2011: 235-236) explain synaesthesia as a mixture of hereditary and environmental factors (inherited propensity to synaesthesia allows the development of particular synaesthetic links through learning and culture), which would explain, as previously mentioned, the increased prevalence of synaesthetic tendencies as the child matures and acquires language.

The theories regarding synaesthesia as a perceptual anchor for processing critical stimuli, as well as a learning aid, are of particular importance in light of the findings of the cross-modal capacities of chimpanzees. Findings of cross-modal meaning-making and detection of audio-visual cross-modal structural isomorphisms in chimpanzees, human’s closest relatives, and the possibility to classify such phenomena as synaesthetic tendencies naturally give way to an array of implications.

3.1 Learning advantages of synaesthesia

Treating synaesthesia, as well as synaesthetic tendencies as a learning aid, highlights their role in normal primate sensory functioning and meaning-making, especially in childhood (Ludwig; Adachi, Matsuzawa 2011: 20661-20663). As previously mentioned, some synaesthetic tendencies appear to be inherited, as is the propensity to develop vivid synaesthesias. The whole process occurs in close relation with the environment in which the human (or, as can be suggested, chimp baby) is born and raised. In this way, particular vivid synaesthesia links could be explained as built upon similar neural mechanisms as the widespread synaesthetic tendencies.

As previously mentioned, certain synaesthetic tendencies seem to develop at certain ages, with four-year-old humans acknowledging similarities between pitch and loudness, as well as loudness and brightness, and older children from the age of eleven perceiving links between pitch and size (Marks 2011: 58), with the former being closer to similarity, and the latter, to metaphorical capacity. Such phenomena are in congruence with what Marks (2011) refers to as unity of senses, stating that, in human cognition, sensory processes might have a leading role, not just a supporting one (Marks 2011: 58). Linguistic capacities, therefore, appear to be essential for more cognitive-type synaesthesias and

synaesthetic tendencies (such as cultural concepts and metaphor). However, even these higher synaesthetic phenomena seem to be built upon sensory processes. Their primary level, which, as I would like to suggest, might have a feedback loop, such as cultural concepts being mapped on gnoseologically earlier sensory categories and, in turn, manifesting themselves in these categories (such as in the cases when cultural concepts, such as days of the week, are perceived as induced perceptual experiences, such as tastes).

Even though chimpanzees seemingly do not have access to verbal language and the higher-level abstractions that it allows to perform, findings about chimpanzee cross-modal meaning-making and detection of audio-visual cross-modal structural isomorphisms are proof that mapping of abstract structures is not a cultural or linguistic phenomenon, but rather a pre-linguistic ability (both in the scale of individual human or chimpanzee development, as well as the evolutionary split between humans and chimpanzees) (Ravignania; Sonnweberb, 2017:78).

As Marks (1975: 326) summarised, synaesthesia is of great importance in childhood as it is an iconic representation. Thus its role diminishes with the acquisition of an abstract language. However, it is closely related to non-synaesthetic experiences, synaesthesia being “a cross-modal manifestation of meaning in its purely sensory, and in one sense its strongest, form” (Marks 1975: 326). Moreover, as stated by Hunt (2005: 29-34), evidence supports the notion that adult synaesthesias are “imagistic forms of semantic reference” or “felt meanings” that can be compared to a specific form of the internalised imagistic side of what Vygotsky referred to as “inner speech”.

Moreover, the tendency to link high pitch and high luminance seems to have evolved between human and chimpanzee lineage split, suggesting that such mapping is a basic characteristic of primate meaning-making sensory system rather than being conditioned by human cognition, culture or language or being a byproduct of the way primate brains processes multisensory information (Ludwig; Adachi, Matsuzawa 2011: 20661-20663). Similar views regarding human synaesthesias were expressed already by Wheeler and Cutsforth (1922: 102), stating that synaesthesia is a normal mental function, “not a surplus process but an essential one [...]”. Since chimpanzees do not possess verbal language but do exhibit synaesthetic tendencies, upon which higher-level abstractions, such as language, metaphor, and induced synaesthetic imagery and experience, can be built, several questions remain: could it be the case that chimpanzees and humans do share the mechanisms necessary for the development of language. However, chimpanzees have not (yet) built upon these mechanisms or are perhaps incapable of doing so due to some other internal factors? Since cross-modal metaphor, according to the synaesthetic spectrum of synaesthetic monism, is treated as less synaesthetic than perceptual similarity, could it be the case that chimpanzees have the means for metaphorical capacity, but it is not expressed? As has been mentioned several times throughout this paper, the

synaesthetic tendencies found in chimpanzees could be compared to those of a small human child; however, while human children grow up to acquire new, more metaphorical synaesthetic tendencies that tend to diminish with age (acquisition of language and consequently increased reliance on abstract cognitive, rather than iconic, sensory processes), no such processes have (yet) been discovered in non-humans. According to the notion of synaesthetic tendencies as normal, basic mechanisms of primate sensory meaning-making, it could even be suggested that the cognitive processes of chimpanzees, not possessing the advanced abstract tools of verbal language, could be even more dependent on primary sensory meaning-making than humans. Subsequently, synaesthetic tendencies, as well as induced synaesthetic imagery and perception (with the latter two not having been researched in non-humans), could also form an integral part of a varying yet unknown degree of chimpanzees' daily lives.

3.2 Evolutionary advantages of synaesthesia

The evolutionary hypothesis about synaesthesia as a cognitive and perceptual aid in recognising, processing, and learning vital stimuli in the environment (Brang; Ramachandran 2011: 3) is in direct relation with the above-discussed "learning-aid" theory. This relation is so as much as it emphasises the innate character of at least some degree and type of synaesthetic phenomena, applicable to both humans and chimpanzees, and is compatible with the idea of both synaesthetic tendencies and vivid synaesthesias possibly sharing the same perceptual roots and functioning mechanisms.

The synaesthetic experience has direct implications on Jakob von Uexküll's concept of *umwelt* as a closed unit formed by the organism's perceptor world and effector world. *Umwelt*, which can be understood as the subjective world of the organism, consists of signs that it receives through sense organs called "receptors", and therefore "sense perception surrounds all living beings like a bubble - clearly delineated but invisible to outside observers" (Uexküll 1992: 281). Since synaesthetic capacities, as discussed before, largely depend on the structural connectivity of the brain and have a proven genetic character, it would not be an exaggeration to claim that a synaesthetic individual is "equipped" with a brain as a central receptor that allows a significantly different sensory and conceptual interpretations and experiences. The fact that synaesthesia is an essential, integral part of a synaesthetic person's *umwelt* can be observed by the many accounts in which synaesthetes admit having never thought of their condition as something special (Ramachandran 2016: 26). This notion can be extended to both humans with vivid synaesthesia, as well as humans and chimpanzees experiencing synaesthetic tendencies.

Generally, the findings about cross-modal similarity and isomorphism capacities of chimpanzees allow proceeding with several hypotheses about human verbal language development. Several researchers have pointed to the intrinsic similarity between metaphorical structuring and synaesthetic perception and cognition processes, suggesting that synaesthetic perception might serve as a key to understanding human symbolic and metaphoric thought and even the origins of verbal language. As stated by Marks (2011: 58), similarities in synaesthetic perception, cognition, and metaphor can be observed, primarily in perception. Further, during development, they become available to more abstract representations in language, such as cross-modal metaphor. Suggesting that metaphor's roots may also reside, like those of synaesthesia, in fundamental cross-modal perceptual similarities. "These inferences suggest that the perceptual roots of synaesthesia might also serve as a root of metaphor per se." (Marks 2011: 58). Moreover, for Marks (1996: 39), synaesthesia is a "notable example of metaphorical perception", with both synaesthetic and physiognomic perception revealing the parallels between various sensory modalities, that have to do, at least in part, with the characteristics of human perception.

In turn, Hunt (2005) states that, according to the synaesthetic internalisation hypothesis for metaphor, the gradual development of metaphor in human beings, which manifests in late childhood, might stem from the underlying synaesthetic capacity of the early development. As Hunt indicates, it is logical in the developmental sense that the unfolding of metaphor in young humans between ages eight and twelve would have its roots in the internalisation of physiognomic and synaesthetic processes as the imagistic side of inner speech (Hunt 2005: 37). Subsequently, the full human symbolic capacity would be a result of open-ended cross-modality translations among vocalisation, kinaesthesia, and vision, that, after their internalisation, would guide the development of metaphoric usage and understanding. Suggesting that "synaesthesias may prove to be the Rosetta Stone for our human symbolic capacity and its form and level of consciousness", with an abundant amount of phenomenological and experimental evidence that adult synaesthesias are imagistic forms of semantic reference (Hunt 2005: 40-41). In this regard, synaesthetic tendencies in chimpanzees could be referred to as a pre-metaphoric state, possessing the necessary mechanisms for metaphoric capacity, which, however, are not developed.

Ramachandran & Hubbard (2001) propose a synaesthesia-based solution to the riddle of language origins and evolution because of (i) sharp phonemic inflexions (such as "kiki") mimicking sharp changes in visual direction and vice versa, suggesting natural constraints for mapping sounds on objects; (ii) sensory-to-motor synaesthesia, such as the rhythm of movements mimicking the auditory rhythm (as in dance), suggests the existence of a natural bias for mapping concrete sounds on certain vocalisations; (iii) the fact that synaesthesia can

cause cross-activation between two motor maps (such as clenching teeth when using scissors) In short:

representation of certain lip/ tongue movements in motor brain maps may be mapped in non-arbitrary ways onto certain sound inflections and phonemic representations in auditory regions and the latter in turn may have non-arbitrary links to an external object's visual appearance. [...] lip and tongue movements and other vocalizations may be synaesthetically linked to objects and events [...] in closer ways than we usually assume, and this may have been especially true early in the evolution of the proto-language of ancestral hominids [...] suggesting that these factors provided the initial impetus for language evolution (Ramachandran; Hubbart 2001: 20-21).

In this way, it can be suggested that synaesthetic tendencies in chimpanzees are a unique example of how human proto-language might have evolved and how the beginnings of human verbal language might have rested on what are essentially synaesthetic tendencies in perception. Consequently, paving the way for further abstraction in the form of language and metaphor, which might have, in turn, lessened the dependency on sensory perception.

4. Conclusion

The aim of this paper has been to research and acknowledge where the visuoauditory mappings between high luminance and high pitch (Ludwig; Adachi; Matsuzawa 2011) and structural isomorphisms across sensory modalities (Ravignani; Sonnweber 2017) discovered in chimpanzees (Pan Troglodytes), which can be classified as synaesthetic tendencies, stand in the framework of some of the most widespread theories of the human synaesthetic experiences. The main findings and conclusions of this paper are as follows:

- 1) The existence of widespread perceptual similarities in the human population, denominated by Marks' (2011) synaesthetic tendencies, as opposed to vivid synaesthesia, allows talking about synaesthetic phenomena as a spectrum ranging from least to most synaesthetic.
- 2) The ("perceptual-behavioural continuum" (Marks 2011)) of the synaesthetic experience corresponds to synaesthetic monism, an inclusive approach to the synaesthetic phenomena that is capable of accommodating the findings about the perception of audio-visual cross-modal similarities and detection of cross-modal isomorphisms in chimpanzees. This could be broadly characterised as synaesthetic tendencies and have equivalents in human multi-modal perception.
- 3) Both vivid synaesthesias, as well as synaesthetic tendencies, despite phenomenological differences, share several structural properties, mapping hierarchy preferences, as well as prevalence trends. As such, suggesting that the

basis of the sensory processing mechanisms of synaesthesia might be shared between synaesthetes and non-synaesthetes alike, further emphasising the continuity of the experience.

4) The similarity of the underlying sensory processing mechanisms allows the synaesthetic spectrum of synaesthetic monism to include both vividly synaesthetic persons, a large part of the general human population experiencing synaesthetic tendencies, as well as non-human individuals (chimpanzees) who experience at least some part of the synaesthetic spectrum.

5) In light of existing studies about the cross-modal abilities of chimpanzees, it can be concluded that chimpanzees are capable of all three cross-modal processing forms found in nature (Ravignani; Sonnweber 2017): discreet mapping, continuous mapping and cross-modal isomorphisms.

6) The extent to which chimpanzees experience synaesthetic phenomena is still scarcely researched. Apart from mappings between high luminance and high pitch, and the recognition of structural isomorphisms between visual and sound structures, chimpanzees could possibly experience a vast array of other synaesthetic phenomena, as exemplified by the multi-faceted nature of the human synaesthetic spectrum.

7) With the intention of fully acknowledging the continuity of the synaesthetic spectrum, the existence of vivid synaesthesias in chimpanzees cannot be ruled out. However, it might be very hard to detect and properly assess, considering the relatively low prevalence and highly idiosyncratic nature of vivid synaesthesias in humans.

8) If human synaesthetic phenomena are to be likened to those found in chimpanzees, the most advisable realms for researching possible vivid synaesthesias in chimpanzees would be the types with sound inducers and colour concurrents, which are the most prevalent sensory vivid synaesthesia types found in humans.

9) The existence of vivid synaesthesia types with cognitive inducers in chimpanzees (such as with time unit inducers and visual concurrents, the most-widespread cognitive type of vivid synaesthesia in humans) is under question since it supposedly entails cultural and language aspects.

10) Human synaesthetic tendencies are widely manifested in language and metaphor, a realm unavailable to chimpanzees. However, how synaesthetic tendencies appear in children (firstly, as cross-modal similarity, which around the pre-teen age develops into the metaphorical capacity) allows the likening of synaesthetic phenomena found in chimpanzees (up to current data) to those observed in pre-teen human children.

11) The pre-linguistic character of synaesthetic tendencies in chimpanzees allows the conclusion that human language, cognition and culture are not a prerequisite for cross-modal abstract mapping. Therefore, synaesthetic tendencies can be considered as basic, primary sensory processing mechanisms for primates that are evolutionary earlier than human linguistic abilities.

12) It is widely shown that primary sensory synaesthetic processing is the prerequisite for the further development of metaphor, abstract thought, and verbal language in humans. It appears that, theoretically, chimpanzees might have the necessary mechanisms for a further metaphorical perception, but these higher-level mappings are not expressed due to an absence of verbal language.

13) Linguistic capacities, therefore, appear to be essential for more cognitive-type synaesthesias and synaesthetic tendencies (such as cultural concepts and metaphor), which chimpanzees do not have access to. However, even these higher synaesthetic phenomena seem to be built upon sensory processes.

14) Since chimpanzees do not have access to the synaesthetic phenomena on the other side of the linguistic threshold, which determines the lessening of the reliance of sensory-type iconic synaesthetic tendencies in humans, it could be the case that chimpanzees are more dependent on primary sensory meaning-making mechanisms than humans. As a result, synaesthetic phenomena might be, to a varying and yet unknown degree, an integral part of a chimpanzee's daily life to a wider extent than it is in humans.

15) The discoveries about the cross-modal capacities of chimpanzees have direct implications on our understanding of chimpanzee umwelt. The kind and extent of these implications depend on future discoveries on the topic.

16) Synaesthetic tendencies in chimpanzees might serve as an example of the structural bases of human verbal language development, highlighting the role of sensory processes in cognition. In this regard, synaesthetic tendencies in chimpanzees could be referred to as a pre-metaphoric state and provide valuable insights into the origins of human verbal language, both at the level of the individual and at the level of the whole human species. Further research on the topic could include testing other primates, or testing chimpanzees for other types of synaesthetic tendencies or vivid synaesthesias, following the data about the prevalence of certain vivid synaesthesia types in humans. The scarcity of current research on the topic leaves a lot for investigation, such as the prevalence of synaesthetic tendencies (and possible vivid synaesthesias) among chimpanzees, the role of learning human-like concepts and their possible serving as cognitive synaesthetic inducers, among others. The findings on synaesthetic tendencies in primates and their possible role as prerequisites for further development of abstract thinking, metaphor, and language raise the question about the role and place of vivid synaesthesias in this process.

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