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Effectiveness Of Action Observation Therapy In Improving Apraxia And Functional Outcomes In Post-Stroke Patients: A Systematic Review

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Abstract

Apraxia is a higher-order motor disorder commonly observed after stroke, characterized by impaired motor planning despite preserved motor strength. Conventional rehabilitation often fails to adequately address this deficit. Action observation therapy (AOT), based on the mirror neuron system, has emerged as a potential intervention targeting motor planning mechanisms. To evaluate the effectiveness of action observation therapy in improving apraxia severity and functional performance in post-stroke patients. A systematic review was conducted following PRISMA guidelines. Literature searches were performed in PubMed, Cochrane Library, and ScienceDirect. Randomized controlled trials evaluating AOT in stroke patients were included. Due to heterogeneity in outcome measures, a qualitative synthesis was performed. Five studies were included. Two studies directly assessed apraxia and demonstrated significant improvements in praxis-related outcomes following AOT. All studies reported improved motor function and functional performance, with greater gains observed in AOT groups compared to conventional rehabilitation. However, findings related to manual dexterity were inconsistent across studies. AOT may enhance motor recovery by facilitating motor planning through activation of shared neural pathways involved in action observation and execution. While evidence supports its benefit in both apraxia-specific and general stroke populations, variability in study design and outcomes limits definitive conclusions.Action observation therapy shows potential in improving apraxia and functional outcomes after stroke, but further high-quality studies are needed to confirm its effectiveness.

Keywords: Action Observation Therapy; Stroke; Apraxia; Motor Recovery; Neurorehabilitation

INTRODUCTION

Stroke remains a leading cause of long-term disability worldwide, with a substantial proportion of survivors experiencing persistent impairments that limit functional independence. Recent epidemiological data indicate a continuous rise in stroke burden, particularly in low- and middle-income countries, where access to comprehensive rehabilitation remains limited (GBD 2021; GBD 2024). While advances in acute stroke management have improved survival, the challenge of optimizing post-stroke recovery, especially in higher-order motor functions, persists.

Among post-stroke deficits, apraxia represents a critical yet frequently underrecognized impairment. It is characterized by the inability to perform purposeful, learned movements despite preserved motor strength, coordination, and comprehension. Apraxia commonly manifests as ideomotor apraxia affecting limb movements or apraxia of speech impacting verbal output. These deficits arise from disruption of cortical networks involved in motor planning and execution, particularly within frontoparietal regions. Importantly, apraxia has been associated with poorer rehabilitation outcomes, reduced functional independence, and prolonged recovery trajectories, making it a significant barrier to effective neurorehabilitation (Goldenberg 2009; Park 2017).

Conventional rehabilitation strategies, including physiotherapy and occupational therapy, primarily emphasize repetitive motor practice to enhance strength, coordination, and task execution. Although these approaches are effective for improving motor output, they often fail to adequately address deficits in motor planning and representation, which are central to apraxia. Consequently, patients with apraxia may demonstrate limited functional gains despite intensive rehabilitation, highlighting a critical gap in current therapeutic paradigm(Langhorne, Bernhardt & Kwakkel 2011; Winstein et al. 2016).

Action observation therapy (AOT) has emerged as a promising intervention designed to bridge this gap by targeting the neural mechanisms underlying motor planning. AOT involves the observation of goal-directed actions followed by their imitation, thereby activating cortical networks associated with both action perception and execution. This process is mediated by the Mirror Neuron System, which plays a fundamental role in motor learning, imitation, and neuroplasticity. Neuroimaging studies have demonstrated that action observation can activate motor-related cortical areas even in the absence of physical movement, suggesting its potential utility in facilitating recovery following neurological injury (Rizzolatti & Sinigaglia 2016; Miguel et al. 2021).

Growing clinical evidence supports the effectiveness of AOT in improving motor function and functional outcomes in patients with stroke. Several randomized controlled trials have reported significant improvements in upper limb motor performance, activities of daily living, and overall functional recovery when AOT is used as an adjunct to conventional rehabilitation. These benefits are thought to result from enhanced motor relearning and cortical reorganization induced by repeated observation-execution coupling (Buccino 2014; Sarasso et al. 2015).

Despite these promising findings, the application of AOT in the context of apraxia remains insufficiently explored. Most existing studies focus on general motor recovery rather than specifically addressing deficits in motor planning. Furthermore, heterogeneity in study populations, intervention protocols, and outcome measures has limited the ability to draw definitive conclusions regarding its effectiveness in apraxia. Given the shared neurophysiological basis between action observation and motor planning, AOT represents a theoretically sound intervention for apraxia; however, a focused synthesis of the available evidence is lacking.

Therefore, this systematic review aims to evaluate the effectiveness of action observation therapy in improving apraxia severity and functional performance in post-stroke patients. By integrating findings from both apraxia-specific and broader motor rehabilitation studies, this review seeks to clarify the role of AOT in addressing motor planning deficits and to provide evidence to guide its clinical application in neurorehabilitation.

RESEARCH METHODS

This systematic review was conducted in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines. The review aimed to evaluate the effectiveness of action observation therapy on apraxia severity and functional outcomes in post-stroke patients through a structured and reproducible methodology. A comprehensive literature search was performed across three electronic databases: PubMed, Cochrane Library, and ScienceDirect. The search strategy was designed to maximize sensitivity by incorporating terms related to action observation therapy, stroke, and neurorehabilitation without restricting to apraxia-specific terminology, given its inconsistent reporting across studies. The search was conducted using the following keywords. PubMed: ("action observation" OR "action observation therapy" OR "action observation training" OR "mirror neuron" OR "mirror neuron system") AND (stroke OR "cerebrovascular accident" OR poststroke OR hemiplegia) AND (rehabilitation OR therapy OR recovery). Cochrane Library: ("action observation" OR "action observation therapy" OR "mirror neuron") AND (stroke OR poststroke OR hemiplegia) AND (rehabilitation OR therapy OR motor OR function OR recovery). ScienceDirect: "action observation" OR "mirror neuron" AND stroke AND rehabilitation OR motor OR recovery. No restrictions were applied regarding publication year at the search stage; however, only studies published in English were considered. The final search results were compiled and screened systematically.

Studies were included if they met the following criteria: participants were adult patients diagnosed with stroke; the intervention involved action observation therapy, either as a standalone or adjunctive treatment; the comparator consisted of conventional rehabilitation or usual care; and outcomes included measures of apraxia severity, motor function, or functional performance. Given the limited number of studies specifically addressing apraxia, studies evaluating motor recovery were also included if they employed action observation therapy and assessed outcomes related to motor execution or functional performance, which are closely associated with motor planning mechanisms. Studies were excluded if they were review articles, case reports, conference abstracts, non-human studies, or if the population did not involve stroke patients. Studies explicitly unrelated to rehabilitation or lacking a comparator group were also excluded.

All identified records were imported and screened for eligibility in a stepwise manner. Initial screening was performed based on titles and abstracts to exclude clearly irrelevant studies. Full-text articles were subsequently assessed for eligibility based on the predefined inclusion and exclusion criteria. A total of 2,000 records were identified through database searching. After title and abstract screening, 1,992 records were excluded. The remaining eight studies were assessed for duplication, resulting in one duplicate removal. Seven full-text articles were evaluated for eligibility, of which two were excluded due to inappropriate study populations. Ultimately, five studies were included in the qualitative synthesis. The study selection process is presented in the PRISMA flow diagram.

Data extraction was performed systematically using a predefined format to ensure consistency across studies. Extracted data included study characteristics such as first author, year of publication, country, study design, population characteristics, sample size, intervention details, comparator, duration of intervention, outcome measures, and key findings. Outcome data were extracted narratively due to heterogeneity in measurement tools and reporting formats. Where applicable, emphasis was placed on direction of effect and statistical significance as reported in the original studies.

The primary outcomes of interest were apraxia severity and functional performance. Apraxia severity was assessed using validated tools such as the Apraxia Screen of TULIA and language-based assessments in cases of apraxia of speech. Functional performance outcomes included motor function and activities of daily living, commonly measured using instruments such as the Fugl-Meyer Assessment, Box and Block Test, Modified Barthel Index, and REACH scale. Given the variability in outcome measures across studies, results were synthesized qualitatively.

The methodological quality of the included studies was assessed using appropriate risk of bias frameworks for randomized controlled trials. Domains evaluated included randomization procedures, allocation concealment, blinding of participants and outcome assessors, completeness of outcome data, and selective reporting.

Due to substantial heterogeneity in study populations, intervention protocols, and outcome measures, a quantitative meta-analysis was not performed. Instead, a qualitative synthesis was conducted to summarize the findings across studies. The synthesis focused on identifying patterns in the direction and magnitude of treatment effects, particularly in relation to apraxia-related outcomes and functional recovery. Studies were grouped based on whether they directly assessed apraxia or indirectly evaluated motor planning through functional and motor performance outcomes.

RESULTS AND DISCUSSION

Study Selection

A total of 2,000 records were identified through database searching, including 306 from PubMed, 283 from the Cochrane Library, and 1,411 from ScienceDirect. After title and abstract screening, 1,992 records were excluded due to irrelevance. The remaining eight records underwent duplicate screening, resulting in the removal of one duplicate. Seven full-text articles were subsequently assessed for eligibility, of which two were excluded due to inappropriate study populations. Ultimately, five studies were included in the qualitative synthesis. The detailed selection process is illustrated in Figure 1.

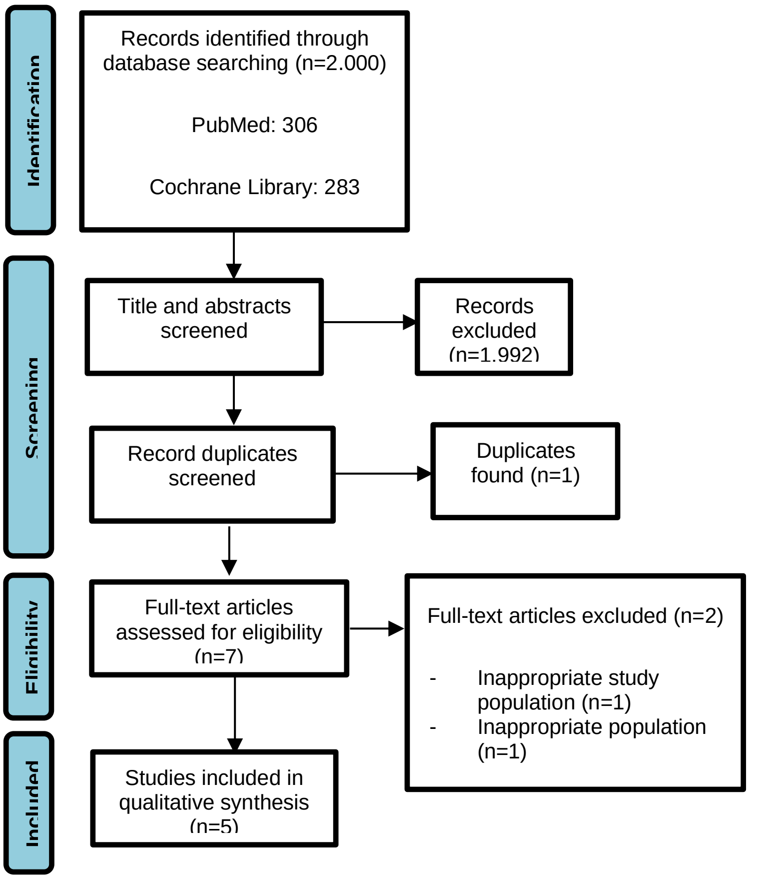

Figure 1. Diagram flow of literature search strategy for this systematic review

Characteristics of Included Studies

All included studies were randomized controlled trials conducted across different regions, including Europe, Asia, and the Middle East. Sample sizes ranged from 22 to 58 participants, encompassing patients in acute, subacute, and early chronic phases of stroke. Two studies specifically evaluated patients with clinically diagnosed apraxia, including ideomotor apraxia and apraxia of speech, while the remaining three studies investigated stroke patients with motor impairment without explicit apraxia diagnosis. Across all studies, the intervention consisted of action observation therapy, typically involving video-based observation of goal-directed actions followed by imitation or task-oriented execution.

Intervention duration varied between 4 and 8 weeks, with frequencies ranging from three to five sessions per week. Control groups received conventional rehabilitation, including physiotherapy, occupational therapy, or task-oriented training without an action observation component. Outcome measures were heterogeneous and included apraxia-specific assessments such as the Apraxia Screen of TULIA and language-based scales, as well as motor and functional outcomes such as the Fugl-Meyer Assessment, Box and Block Test, Modified Barthel Index, and REACH scale.

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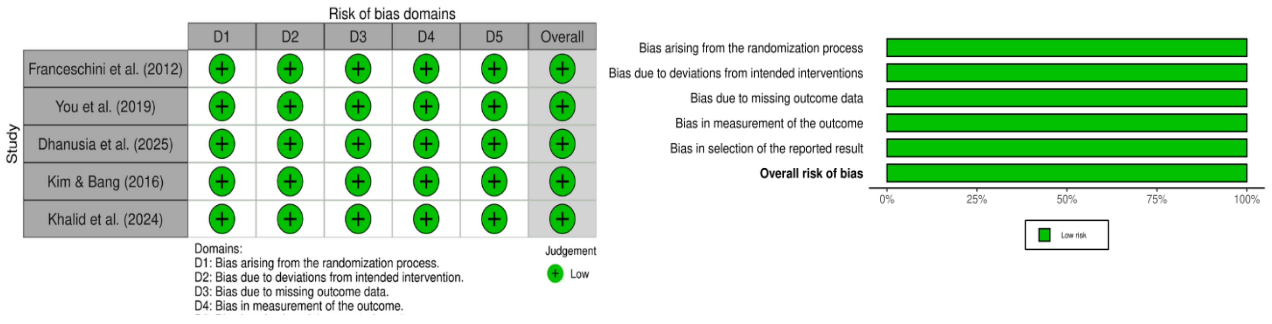

Figure 2. Risk of bias assessment result using RoB-2 from Cochrane

Table 1. Characteristics and results of the included studies

irst Author (Year)	**Country / Setting**	**Study Design**	**opulation (Stroke + Apraxia)**	**ample Size (I/C)**	**ean Age (I/C)**	**Intervention (Action Observation Therapy)**	**Comparator (Conventional Rehab / Usual Care)**	**Duration/ Follow-up**	**Outcomes Measured**	**Summary of Findings**	**isk of bias**
ranceschini et al. (2012)	Italy (Multi - center, 13 rehab centers)	Randomized controlled observer-blind trial	irst-ever stroke patients (~30 days post-stroke); ideomotor apraxia assessed but not exclusive inclusion criterion	3 / 49 (analyzed: 40 / 39)	7.0 ± 12.4 / 65.7 ± 11.9	Video-based AOT of daily upper-limb tasks (goal-directed, ADL-based); 3 sequences/ task; imitation after observation; 2 sessions/ day (15 min each), 5 days/week for 4 weeks	Sham observation (static images) + matched upper-limb mobilization exercises without action imitation	4 weeks treatment + 4–5 months follow-up	Fugl-Meyer (FM), Frenchay Arm Test (FAT), Box and Block Test (BBT), Modified Ashworth Scale, FIM Motor	Both groups improved over time; significant Time × Treatment interaction favoring AOT only for BBT (dexterity) at T0–T1 and T0–T2; no significant difference for FM and FIM → suggests selective benefit on functional dexterity	ow
ou et al. (2019)	China (Nanjing Brain Hospital)	Randomized controlled trial	ost-stroke patients with apraxia of speech (AOS) (1–6 months post-stroke; mostly with aphasia)	1 / 21	6.52 ± 12.29 / 58.71 ± 12.00	AOT based on mirror neuron theory: video-based observation of goal-directed hand + mouth actions with auditory cues, followed by repetition; 20 min/day + conventional therapy	Conventional language therapy only (30 min twice daily)	4 weeks (no long-term follow-up)	AOS assessment (China Rehab Research Center), Western Aphasia Battery (WAB: fluency, comprehension, repetition, naming), Boston Diagnostic Aphasia Examination (BDAE)	Both groups improved; AOT group showed significantly greater improvement in AOS scores, WAB domains (fluency, comprehension, repetition, naming), and overall response rate (76.19% vs 61.90%) → strong evidence	ow

										AOT improves speech motor planning and language function	
hanusia et al. (2025)	India (Saveetha College of Physiotherapy, Chennai)	Randomized controlled trial (assessor-blinded)	Stroke patients with ideomotor apraxia (IMA) (age 25–60; first-ever stroke; confirmed via AST criteria)	0 / 20	9.75 ± 9.31 / 42.10 ± 8.96	AOT + conventional physiotherapy: video-based observation of goal-directed upper limb actions (transitive, intransitive gestures, reaching tasks) + imitation practice	Conventional physiotherapy only (tactile stimulation, strengthening, functional task training)	6 weeks (4 sessions/ week)	Apraxia Screen of TULIA (AST), Fugl-Meyer Assessment Upper Extremity (FMA-UE)	Both groups improved significantly; AOT group showed significantly greater improvement in apraxia (AST: 10.20 vs 7.90) and motor function (FMA-UE: 59.65 vs 52.75), p < 0.001 → strong evidence AOT enhances motor planning and upper-limb recovery	o w
im & Bang (2016)	South Korea (University rehabilitation hospital)	Double-blind randomized controlled pilot trial	Subacute stroke patients (1–6 months) with moderate upper limb impairment (no explicit apraxia diagnosis)	1 / 11	2.78 ± 9.85 / 61.49 ± 8.64	AOT: video-based observation of ADL-related upper limb tasks (multi-angle, variable speed) followed by imitation + task-oriented training	Task-oriented training only (same tasks without observation)	4 weeks (5 sessions/ week, 40 min/session)	Fugl-Meyer Assessment Upper Extremity (FMA-UE), Box and Block Test (BBT), Modified Barthel Index (MBI), Modified Ashworth Scale (MAS)	AOT group showed significantly greater improvements in motor function (FMA-UE), dexterity (BBT), and ADL performance (MBI) compared to control (p<0.05); no significant difference in spasticity (MAS) → supports AOT for motor recovery	o w
halid et al. (2024)	Pakistan (Rafsan Neuro Rehab Center, Peshawar)	Randomized controlled trial (double-blinded)	Acute stroke patients (explicitly excluded	9 / 29	3.28 ± 9.21 / 54.83 ± 9.64	AOT: observation of complex upper-limb tasks via video followed by	Conventional therapy only	8 weeks	Fugl-Meyer Assessment (FMA), Box and Block Test (BBT),	AOT group showed significantly greater improvement in motor function	o w

			apraxia)			execution (mirror neuron–based motor learning)			REACH scale	(FMA) and functional recovery (REACH) vs control ($p = 0.01$); no significant difference in dexterity (BBT) → AOT improves motor recovery but not consistently dexterity	

Effects of Action Observation Therapy on Apraxia

Among the included studies, two directly assessed apraxia outcomes. Both studies consistently demonstrated that action observation therapy was associated with greater improvements in apraxia severity compared to conventional rehabilitation. In patients with ideomotor apraxia, action observation therapy led to higher post-intervention scores on standardized praxis assessments, indicating improved motor planning and execution. Similarly, in patients with apraxia of speech, significant improvements were observed in language-related functional domains, including fluency, repetition, and naming abilities. Although outcome measures differed between studies, the direction of effect was consistent, suggesting that action observation therapy may effectively target deficits in motor planning that characterize apraxia.

Effects on Motor Function and Functional Outcomes

All included studies reported improvements in motor function following intervention in both experimental and control groups. However, studies consistently demonstrated that patients receiving action observation therapy exhibited greater improvements in upper limb motor function and functional recovery compared to those receiving conventional rehabilitation alone.

Improvements were observed across multiple domains, including motor performance, functional independence, and task execution. Studies assessing activities of daily living reported enhanced functional outcomes in the action observation groups, indicating a potential translation of motor gains into meaningful clinical improvement.

In contrast, findings related to manual dexterity were less consistent. While some studies reported improvements, others did not observe significant differences between intervention and control groups. This variability may be attributed to differences in task complexity, assessment tools, and intervention protocols.

Qualitative Synthesis of Findings

Due to heterogeneity in study populations, intervention protocols, and outcome measures, quantitative synthesis was not feasible. Instead, a qualitative synthesis was performed. Across all included studies, a consistent trend emerged demonstrating that action observation therapy, when used as an adjunct to conventional rehabilitation, provides additional benefits in motor recovery and functional performance. Notably, studies targeting apraxia directly showed improvements in motor planning and execution, while studies involving general stroke populations demonstrated improvements in motor output and functional independence.

These findings collectively suggest that action observation therapy may exert its effects through shared neural mechanisms related to motor representation and execution, thereby supporting its use in both apraxia-specific and broader stroke rehabilitation contexts.

Discussion

This systematic review suggests that action observation therapy may provide meaningful benefit for post-stroke patients with apraxia or apraxia-related motor planning deficits. Across the included studies, AOT was consistently associated with improvement in motor performance, functional recovery, and, in apraxia-specific populations, praxis or speech-related outcomes. This finding is clinically relevant because post-stroke apraxia is not merely a weakness-based impairment, but a disruption in the ability to translate intention into organized, purposeful movement. Therefore, an intervention that reinforces action perception, motor representation, and imitation has a strong theoretical basis for this population (Goldenberg 2009; Langhorne et al. 2011; Rizzolatti & Sinigaglia 2016; Winstein et al. 2016; Park 2017; Miguel et al. 2021).

The most direct evidence came from studies involving patients with ideomotor apraxia and apraxia of speech. In ideomotor apraxia, AOT improved praxis performance and upper-limb motor function, while in apraxia of speech, AOT improved speech motor programming, oral expression, repetition, naming, and comprehension. These findings indicate that the therapeutic effect of AOT may extend beyond simple motor execution and may involve higher-order motor planning networks, which are central to both limb apraxia and speech apraxia (You et al. 2019; Dhanusia et al. 2025).

The benefit of AOT is likely mediated through the mirror neuron system and broader action observation network, which links observed actions with internal motor representations. During AOT, patients repeatedly observe goal-directed actions and then attempt to imitate them, creating a perception–execution loop that may strengthen impaired motor programs. This mechanism is particularly relevant in apraxia, where the main deficit lies in action selection, sequencing, gesture representation, and transformation of intended movement into correct execution (Langhorne et al. 2011; Rizzolatti & Sinigaglia 2016; Winstein et al. 2016; Miguel et al. 2021).

In stroke rehabilitation, this mechanism may be useful because it allows patients to engage motor-related cortical networks even before or during limited voluntary movement. This is especially important for patients with apraxia, who may understand the task but fail to produce the appropriate gesture or movement pattern. Through repeated observation of meaningful actions, AOT may provide an external template for reconstructing motor plans and improving action organization (Sarasso et al. 2015; Miguel et al. 2021).

The findings of this review are consistent with broader evidence supporting AOT in stroke rehabilitation. Previous reviews have reported that action observation can improve upper-limb motor function and activities of daily living after stroke, although effects may vary depending on intervention intensity, task specificity, and patient characteristics (Buccino 2014; Sarasso et al. 2015). The present review adds a more focused perspective by highlighting its potential relevance for apraxia, particularly because apraxia involves disruption of action representation rather than isolated motor weakness.

However, the evidence remains uneven. Studies directly targeting apraxia remain limited, while several included studies assessed general stroke motor impairment rather than formally diagnosed apraxia. These indirect studies still support the biological plausibility of AOT because they demonstrate improvement in motor execution, dexterity, and functional task performance after observation-based training. Nevertheless, they should not be interpreted as direct proof of apraxia recovery. Instead, they provide supportive evidence that AOT can enhance motor learning pathways that overlap with praxis-related networks (Buccino 2014; Sarasso et al. 2015; Kim 2020; Khalid et al. 2024)

The overall direction of findings favored AOT, but the magnitude and domain of improvement varied across studies. Improvements were more consistent for global motor function and functional performance than for manual dexterity. This may be because dexterity requires more refined sensorimotor control, object manipulation, and speed-dependent coordination, which may not fully recover through observation alone. In contrast, broader motor and functional outcomes may be more responsive to AOT because they involve repeated task execution and ADL-oriented motor relearning.

Differences in intervention protocols may also explain variability. Some studies used simple upper-limb videos, while others used complex ADL-based actions, speech-related actions, or combined mouth–hand–voice observation. Duration also ranged from 4 to 8 weeks. These differences suggest that AOT is not a single uniform intervention; its effectiveness likely depends on whether the observed actions are meaningful, task-specific, repeated, and directly matched to the patient's functional deficit (Francisco et al. 2024).

Clinically, AOT appears to be a feasible, low-cost, and safe adjunct to conventional rehabilitation. It can be delivered using videos, therapist demonstration, or structured task observation, making it practical in settings with limited rehabilitation resources. For post-stroke apraxia, AOT may be especially useful when integrated with occupational therapy, speech therapy, and task-oriented practice, because it provides a structured visual model before execution.

For limb apraxia, therapy should prioritize meaningful ADL-based gestures, object-related actions, and imitation tasks. For apraxia of speech, multimodal AOT involving mouth movements, hand gestures, and auditory cues may be more suitable. Rather than replacing conventional therapy, AOT should be viewed as an add-on strategy that strengthens motor planning before or during physical practice (Francisco et al. 2024; Dhanusia et al. 2025).

Several limitations should be acknowledged. First, only a small number of studies directly investigated apraxia, and the remaining studies involved broader stroke motor impairment populations. Second, sample sizes were generally small, and most studies were single-center trials. Third, intervention protocols were heterogeneous, making it difficult to determine the optimal dose, duration, and action type. Fourth, long-term follow-up was limited, so the durability of treatment effects remains uncertain.

Another important limitation is outcome heterogeneity. Apraxia-specific outcomes such as AST, TULIA, or speech apraxia scales were not consistently used across studies. This limited the ability to compare findings across studies and prevented quantitative synthesis. Future studies should use standardized apraxia-specific measures alongside functional scales to clarify whether improvement reflects true praxis recovery or general motor improvement.

Future research should prioritize well-designed randomized controlled trials specifically enrolling post-stroke patients with diagnosed limb apraxia or apraxia of speech. These studies should clearly define apraxia subtype, lesion characteristics, stroke phase, intervention protocol, and comparator treatment. Longer follow-up is needed to determine whether AOT produces sustained functional gains. Additionally, future studies should compare different AOT formats, including video-based, therapist-led, virtual reality–assisted, and multimodal observation approaches.

A particularly important direction is the development of apraxia-specific AOT protocols. For ideomotor apraxia, this may include transitive and intransitive gesture training, object-use sequences, and ADL-based imitation. For apraxia of speech, protocols should incorporate articulatory observation, auditory cueing, and speech imitation. Such tailored approaches may help transform AOT from a general stroke motor intervention into a targeted therapy for post-stroke apraxia.

CONCLUSIONS

Action observation therapy appears to be a promising adjunctive intervention for post-stroke rehabilitation, particularly in addressing deficits related to motor planning and functional performance. Evidence from this review suggests that AOT may improve apraxia severity, especially in ideomotor apraxia and apraxia of speech, while also enhancing motor function and activities of daily living in broader stroke populations.

Despite consistent positive trends, the current evidence remains limited by small sample sizes, heterogeneous outcome measures, and a scarcity of studies specifically targeting apraxia. Therefore, while AOT demonstrates strong mechanistic plausibility and clinical potential, further high-quality, apraxia-focused trials are required to establish its definitive role in neurorehabilitation.

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